PUBLISHED EVERY SATURDAY BY

THE W. J. JOHNSTON COMPANY, Limited,

167-177 TIMES BUILDING, NEW YORK.

Established 1874. Incorporated 1889.

Telephone Call: Cortlandt 924. Cable Address: "Electrical," New York.

New England Office, Room 28, Hathaway Building, 620 Atlantic Ave., Boston.

Western Office, 465 The Rookery, Chicago.

Philadelphia Office, 927 Chestnut Street.

SUBSCRIPTION, IN ADVANCE, ONE YEAR, $3.

(Including Postage in the U. S., Canada or Mexico.)

IN CLUBS of four or more, $2.50 a year each; with a free extra copy to the getter up of a club of 8. Foreign subscription, $6 a year.

In requesting your address changed, give **old** *as well as new address.*

ESTABLISHED 17 YEARS AGO, THE ELECTRICAL WORLD is the Pioneer Electrical Journal of America and has well maintained its lead. It has the LARGEST CIRCULATION of any electrical periodical in the world, and is the BEST ADVERTISING MEDIUM.

Advertising Rates are much lower than those of any other similar publication, circulation and standing considered, and vary according to space, position and number of insertions. Quotations promptly furnished.

Situation or Help Wanted advertisements $1 to $2 an insertion, according to length.

Address all communications to

THE W. J. JOHNSTON COMPANY, Ltd.

Times Building, New York,

OR ANY OF THE BRANCH OFFICES.

VOL. XVII. NEW YORK, MAY 9, 1891. No. 19.

CONTENTS.

EDITORIAL: PAGE.

Paragraphs ... 337

ILLUSTRATED ARTICLES:

ELECTRICAL WORLD Portraits: XXIV., Prof. Oliver J. Lodge ... 338
An Isolated Plant in Brooklyn ... 339
Alternating-Current Electric Motors, I.; by Dr. Louis Duncan ... 341
Henry's Electric Motor Constructed in 1831, by J. Elfreth Watkins ... 342
Graphic Method of Analyzing Losses in Armature Cores, etc., by R. H. Housman ... 342
An Electrostatic Commutator, by Rollo Appleyard ... 342
Wimhurst's Alternating Influence Machine ... 343
The Magnetic Circuit of Transformers: Closed versus Open, by S. Eversheds ... 344
Notes on the Design of Multipolar Dynamos, by W. B. Esson ... 346
Electric and Magnetic Screening, by Sir William Thomson ... 346
The Solano High-Speed Engine ... 348
The Bagnall Fuse Switch ... 348
The McCann Signaling System ... 348
Cope's Wire Tightener ... 348
A New Water Motor ... 348

MISCELLANEOUS:

Latest Foreign Electrical News ... 338
New Book: The Electroplaters' Handbook ... 338
Damage by Lightning, by N. D. C. Hodges ... 338
Common Sense from Chicago ... 338
Electric Welding ... 339
High-Power Batteries ... 339
History of Electricity, Galvanism, Magnetism and the Telegraph, by P. F. Mottelay ... 340
Ganz Alternate Current Motors ... 342
Electricity in Mill Work, by C. S. Hussey ... 343
Annual and General Meeting of the American Institute of Electrical Engineers ... 344
The Superposition of Longitudinal and Transverse Magnetization ... 347
Statistics of Street Railways ... 347
Long-Distance Railway Work ... 348

FINANCIAL INTELLIGENCE: The Electrical Stock Market, 349; New Incorporations, 349; Affairs of the Companies, 349.

SPECIAL CORRESPONDENCE: New York Notes, 349: New England Notes, 349; Philadelphia Notes, 350; Western Notes, 350; Southern Notes, 350.

ANSWERS TO CORRESPONDENTS ... 350

NEWS OF THE WEEK: The Telegraph, 350; The Telephone, 350; The Electric Light, 350; The Electric Railway, 351; Personals, 351; Legal Notes, 351; Miscellaneous Notes, 351.

INDUSTRIAL AND TRADE NOTES ... 351

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS ... 352

Isolated Lighting Plants.

OUR cable dispatch this week calls attention to the activity of our English cousins in installing isolated plants, and that in spite of comparatively low rates and much competition among electrical companies. It is a pity that there are as yet no complete statistics of isolated lighting in this country. Were such a collection to be made it would probably be a revelation to most of those who are interested in electrical industry. In large manufactories and shops where power for general purposes is available, isolated lighting can be carried out with the greatest success, and at a rate with which companies having to distribute over any considerable area cannot successfully compete. About a year ago we published some very striking figures apropos of this subject, showing the cost of lighting a large office building. The figures were almost absurdly low, and yet they were thoroughly authentic. Not only did they show successful competition with electric lighting as furnished by central stations, but with gas obtained even on the most favorable terms. Electric lighting companies really need have very little fear on the score of private installations, because while the establishment of these may mean the loss of some revenue, it also means a blow at their particular rivals who furnish gas of bad, or worse, quality for the alleged purpose of illumination. Most manufacturers who have had experience with incandescent lamps want no more of gas from that time on forever, and so, while the lighting of a great hotel or office building from a plant of its own may occasionally cost a throb of pain in the hearts of electric lighting managers, it really furthers their cause as almost nothing else could.

Joseph Henry's Electric Motor.

ON another page will be found a cut of one of the earliest electric motors ever constructed, designed by no less an investigator than Joseph Henry, in the year 1831. As the description shows it was exceedingly simple, a balanced bar electromagnet with subsidiary magnets at either end, and commutators of the mercury cup sort, so placed as to reverse the currents at each tilt of the bar. The result, of course, was a true electromagnetic engine that with proper arrangements could have been made to produce rotary motion. It took a very long time to evolve an electric motor that would produce a continuous rotary effort. The first step, perhaps, was the two-part commutator with a crude revolving armature to replace Henry's reciprocating arrangement. But the step from these rudimentary machines to the modern motor was one that was too long to be taken readily. Barlow's wheel, the motor prototype of Faraday's disc machine, is perhaps an exception. But nothing effective could be done until the discovery of the reversibility of the dynamo. It is a curious thing, by the way, that inventors ever since the time of Henry have now and then reverted to the clumsy reciprocating arrangements that one might suppose would have completely disappeared by reason of their peculiar inefficiency. Several reciprocating motors have been patented within the last few years, with what object it is somewhat difficult to determine. Still, the reciprocating motor, like the primary battery that consumes no zinc to speak of and costs a minus quantity for depolarizing solution, will probably stay with us as long as there still survive human beings ignorant of the laws of energy, and the United States patent office continues in active operation.

Electric and Magnetic Screening.

SIR WILLIAM THOMSON'S lecture on "Electric and Magnetic Screening," published elsewhere in our columns, is thoroughly characteristic of the man. He has the gift in a rare degree of being able to drop the abstruse mathematics in which he delights to revel and give practical results reached by very simple methods of reasoning. At first sight, his division of different kinds of screening seems whimsical, including as he does both fire screens and window blinds. But it is rather serious joking, for one must realize that a fire screen checks electromagnetic radiation of a certain character as completely as a tinfoil screen protects an electrometer from external influences. Of course, electrostatic screening is the kind most familiar to us from the text-books, but practically perhaps the least important of the varieties enumerated. One of the diagrams given shows admirably the character of the protection against electrostatic influences afforded by gratings of the general character of a bird cage. Perhaps the most interesting portion of the distinguished scientist's remarks were those on magnetostatic screening of iron; it is generally understood, of course, that to a certain extent the interposition of a mass of soft iron between two magnets tends to lessen the action between them, but it is not so well known that to screen completely from magnetic effects a preposterously large amount of iron is necessary. One very practical application of this principle is found in the anti-magnetic shields frequently worn to protect watches from the malign influence of the stray field of dynamos and motors. Such shields unquestionably have some effect, but the possessor of one must not be tempted to test its power too completely; for, while the thickness of the iron is great enough to very much reduce the magnetizing force of the field magnets, the apparatus is not intended or suited to resist very strong magnetizing forces; indeed, to do so effectively would require a thickness of something like a quarter of an inch; in other words, more than would be convenient in practice. Still another application mentioned especially by Sir William Thomson, is the inadequacy of a ship's hull to screen compasses from the electromagnetic action of the electric light currents on board in cases where the method of "single wiring" has been employed; a practice that is, fortunately, for the most part abandoned at present, but this warning against it should not be forgotten.

Alternating Current Motors.

WHEN we take into consideration the immense advantages that could be attained by the use of a thoroughly practical alternating current motor, it seems rather remarkable that in the course of the last two or three years so little has been done toward producing a thoroughly available machine. Except for innumerable patents, of which little is heard, the state of the art does not seem to have materially advanced. Dr. Duncan's able general discussion of the whole subject, of which the first part is published this week, will give our readers some idea of the discouraging, as well as the encouraging, factors of the case. To build an alternating current motor of reasonable efficiency and good mechanical properties is easy; but to make it start itself, stand up to its work under changes of load, and do various other things that are required to be done in practice, is a task that has well nigh defied the ingenuity of inventors. In the first place, it is to be remembered that an alternating current, even when redressed, is not at all equivalent to the continuous current for magnetizing purposes. To attempt to employ it in such a way is simply flying in the face of hysteresis; and unless the amount of iron affected is very much smaller than is usually found, the results will be unpleasant. When the Tesla type of motor appeared there was great rejoicing among electricians for the ingenuity of the principle, and its effectiveness in an experimental way was most fascinating. Nevertheless three years or so have passed and nothing very practical has come of it, more from minor difficulties than from any fault of the principle involved. The synchronizing motor, in other words an alternating dynamo run backwards, has found employment in a certain number of cases, but for general use the difficulty in starting is a very serious objection; this has been partially overcome in the Ganz motors that are finding their way into commercial work in Germany. But all in all it is only too evident that the conditions of real success in alternating motors are rather imperfectly understood. Dr. Duncan's discussion of the matter is of particular interest, as he has worked at the problem quite persistently for the past five or six years, so far as academic duties permitted, and is one of those to whom we naturally look for practical results. Experimenting on alternating current motors is not an altogether easy task, for it is really working in the dark. For the most part it is next to impossible to tell *d priori* what the ultimate result of a certain combination of parts may be; an approximate result can be told pretty clearly from theory, but just how it is going to be disturbed in practice is a particularly exasperating puzzle. The theory of the continuous current machine has been well worked out, but even in it there are very imperfectly known factors, such, for example, as the apparent change of magnetic resistance in the air gap under varying load. The design of alternating current apparatus is by no means as thoroughly understood, and if, as Dr. Duncan suggests, the various workers in the field can be exasperated into giving such facts as are in their possession, a very excellent work will have been done for applied science.

The Economy of Electric Traction.

CENSUS bulletin No. 55, on the relative economy of cable, electric and animal motive power for street railways, furnishes an interesting bit of reading for electricians. The figures are based on authoritative statistics gathered by the agents of the Census Office, and are presumably reliable; at least sufficiently for purposes of comparison. The roads under consideration are 50 in number, 10 of them cable roads, 10 electric roads and 30 horse railroads. The compiler of the report has carefully tabulated the cost of road and equipment, statistics of passengers, and all the details of the cost of operation for each road. The first thing to strike the investigator is that these figures completely refute the claim frequently made in behalf of cable roads that their actual cost is very little in excess of electric roads. We can, fortunately, select for comparison a cable road and an electric road operating very nearly the same length of line. The former covers 5¼ miles of street, double-track; it cost $1,467,000, and carried in 12 months over 10,000,000 passengers; the operating expenses per car mile were 21½ cents, and, per passenger carried, 3.54 cents. The electric road was single track, six miles long, and cost $115,000. It carried a little less than a million passengers per year, at a cost per car mile of 13.68 cents, and, per passenger carried, 2.71 cents. A comparison will show that the electric road cost per mile less than one-tenth the cable road, carried only about a tenth as many passengers, and yet beat its competitor on operating expenses per car mile and profit per passenger by something like 30 per cent. The average results from these ten roads of each kind are as follows: The cable railways showed operating expenses of 14.12 cents per car mile, and, per passenger carried, 3.22 cents; the electric railways cost to operate 13.21 cents per car mile but 3.82 cents per passenger carried. The cause of this discrepancy is not far to seek, because the electric roads are for the most part in comparatively small cities, and the number of passengers carried per car mile is necessarily rather small. The most striking advantage of the electric road is of course, the low first cost for the service done. This may be effectively emphasized by comparing a certain cable line with an electric line of nearly the same length of track and just the same number of cars. The electric line suffers under the disadvantage of being single-track and consequently having a relatively costly overhead structure; it is 16 miles in length and operates on the average 32 cars; the total cost was $1,156,000. The cable road operates a total of 11 miles of track, covering, therefore, less than half the street length of its competitor; the same number of cars are in regular use, while the total cost was $2,628,000; considerably more than twice that of the electric line operating over double the miles of street. The expenses per car mile were, for the cable road, 14.16 cents; for the electric, 13.53 cents. The two things that stand out most prominently on a careful study of the statistics are these: That for equipments of similar capacity the electric road costs enormously less than cable roads, and second, that for anything like equal amounts of traffic, with the same equipment, the electric road would flourish where a cable road would go into bankruptcy.

Latest Foreign Electrical News.

(By cable from our regular correspondent.)

London, May 4, 1891.—At a meeting of the Metropolitan Electric Supply Corporation on Wednesday last the chairman stated that it was contemplated ultimately to adopt transformer sub-stations generally. It was found at present that each 8 c. p. light connected yielded an annual rental of only 12 shillings, showing that the average daily use was only about an hour and three-quarters. In spite of the existence of numerous electric light companies many large isolated plants are being laid down, as, for instance, at the headquarters of the metropolitan police and many other important points.

The electrical exhibition at Frankfort-on-the-Main is finally announced to open on the 15th of May. It is, however, unfortunately in a somewhat backward state, and all the exhibits will not be in place until late in the summer.

On the graduation day of Glasgow University the students presented an address to Sir William Thomson congratulating him on his election to the presidency of the Royal Society.

The death is announced of Zede, one of the designers of the electric torpedo boat La Gymnote. It will be remembered that this boat made something of a sensation about two years ago by its very successful manœuvres in one of the French harbors. It was equipped with a 60 h. p. electric motor, driven by Desmazures storage batteries. For one reason or another it has not been much heard of since.

NEW BOOK.

The Electroplater's Handbook, by G. E. Bonney. Pp. 206; 61 illustrations. New York: D. Van Nostrand & Co., 1891. London: Whittaker & Co.

This little volume is specially adapted for the needs of amateurs and experimenters who desire a practical manual of electroplating. It presupposes a slight knowledge of electricity, but nothing more than any one who would wish to take up electroplating may be fairly supposed to have. The information given in it has been proved in the workshop. After a brief chapter on the general subject of electro-deposition of metals, the volume goes on to give some account of proper batteries for electroplating, their construction, care and arrangement, and afterward takes up the dynamo for electroplating, describing a number of common types and giving some idea of their various properties. In discussing this topic it is rather a pity that more details of the latest types of plating dynamo are not given, as the descriptions which appear only in part relate to recent machines, and take notice of some that are utterly unworthy of it. Good designing is just as important in plating machines as in dynamos for incandescent lighting, in spite of the bad practice that has usually beset the former class of machines. A succeeding chapter on electroplating materials is full of useful practical hints to the beginner; and the remaining part of the book, comprising explicit directions for different sorts of electroplating, will be thoroughly appreciated by beginners in the art. Altogether it is an unpretentious little volume, full of practical information on a subject that is usually neglected or else treated in such formidable detail that the amateur is frightened away from it.

ELECTRICAL WORLD PORTRAITS.—No. XXIV.

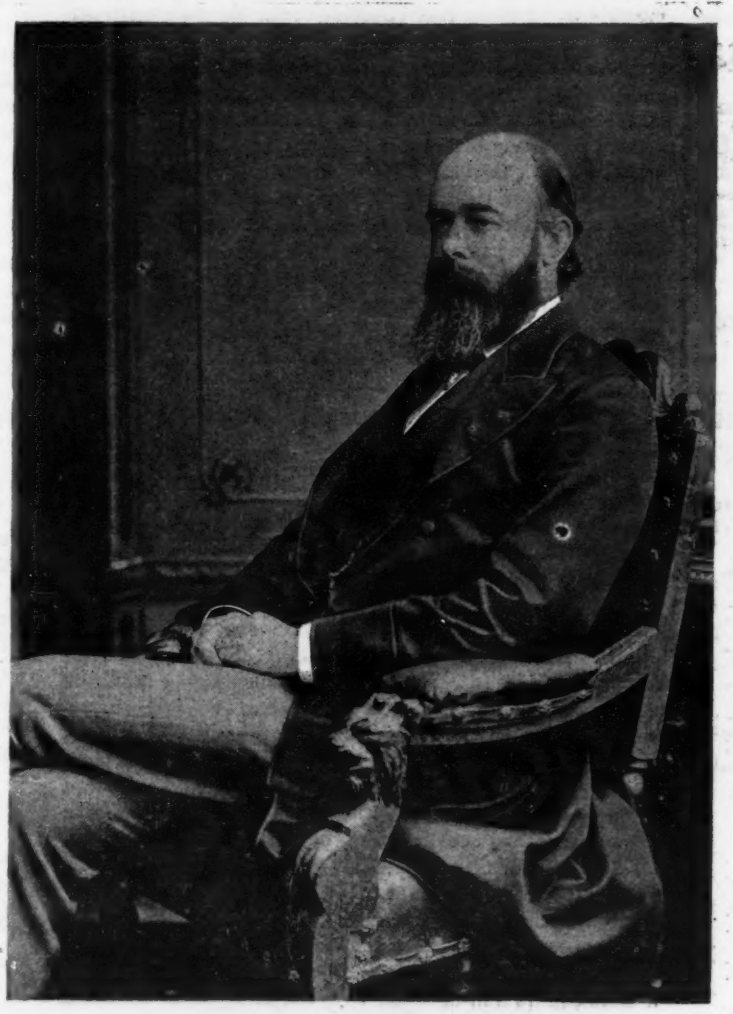
PROFESSOR OLIVER J. LODGE.

Few electricians are more widely known to-day than Dr. Lodge, who has made an enviable reputation through his elaborate research work and persistent enthusiasm in championing modern ideas.

Oliver J. Lodge was born just forty years ago at a little town near Stoke-upon-Trent, England, and after a grammar school education was put into business with his father in The Potteries, where he remained several years. It was during this period that he made his first acquaintance with science by reading such odd bits as he could find in popular literature and stray periodicals. A little later, on a visit to London, he heard a series of Tyndall's brilliant lectures, and began the study of elementary chemistry. Later still he attended afternoon classes in chemistry at Wedgewood Institute; and in 1872 followed up the subject by a winter's course at the South Kensington chemical laboratory.

About the same time, by working and studying at odd hours, he matriculated at the University of London, and shortly after began the study of mathematics at University College, London, where Prof. Carey Foster interested himself in the young student, and enabled him to make his own way by teaching in exercise classes. In 1875 he took his degree as bachelor of science, and then was selected to fill the post of demonstrator of physics at University College. In the same year he published, with Prof. Foster, several papers on the flow of electricity in plane conductors that attracted considerable attention in the scientific world. The next year he continued his electrical studies and exhibited before the British Association a model derived from Maxwell's theories for the purpose of illustrating mechanically the passage of electricity through metals, electrolytes and dielectrics. In June, 1877, he published a paper on electrical measurements, and later in the year brought out a research on the standard of electromotive force, taking for this purpose the Daniell cell. In 1887 he took his degree as doctor of science choosing experimental electricity as his special subject. In the autumn he became assistant professor of physics at University College, and began his brilliant career as a lecturer. He was also lecturer in physics at Bedford College, London, and, in addition to these appointments he assisted the late William Kingdon Clifford in the mathematical work at University College. During this period Dr. Lodge was steadily engaged in research work, and devoted much attention to the conductivity, thermo and electric, of metals and other substances.

A couple of years later, after the telephone and the Hughes induction balance had attracted the attention of the scientific world, Dr. Lodge bent his attention toward the phenomena of mutual and self-induction, and produced a clever mathematical theory of intermittent currents in the induction balance. The facts observed by Hughes were here accounted for and explained, but more than this, his work familiarized students with the properties of self and mutual induction in closed circuits. In 1881 Dr. Lodge



PROFESSOR OLIVER J. LODGE.

was elected to the professorship of physics and mathematics in the University College in Liverpool, and in the subsequent year his time was largely occupied in superintending the erection and equipment of a physical laboratory, besides delivering lectures both in physics and mathematics. Later the chair of mathematics was endowed, and Prof. Lodge thus relieved from the work that had for the time being stifled his researches. He then began a series of experiments on secondary batteries, and acted as scientific adviser to the Electrical Power Storage Battery Company. This field of storage he thoroughly explored, and took out several useful patents on the subject.

At the British Association meeting in Montreal, in 1884, Dr. Lodge was present and opened the first formal discussion in the physical section; this was on the seat of electromotive force in the voltaic cell, and was followed up a little later by a brilliant paper on the path of energy in voltaic circuits. At the next meeting of the British Association he opened the discussion on electrolysis, and for the following two years much of his attention was directed to the theory of this subject. In 1887 he began the series of experiments by which he is perhaps best known, those on waves in conductors and on Leyden jar discharges. Since that time his experiments have followed closely along the lines laid down by Maxwell in his electromagnetic theory of light, and he has done invaluable work in strengthening the theory experimentally, and extending the beautiful work that was done by Hertz at about the same time.

At the end of 1887, as the result of this theoretical study, Prof. Lodge published his views on ether theory and the mechanics of the propagation of light and electricity. These articles were collected into a book, and issued in 1889 under the title of "Modern Views of Electricity." It is by this book that Prof. Lodge is perhaps best known. He has done magnificent service in popularizing the abstruse and complicated ideas that beset the modern theories of electricity. It may be that he has gone too far in this direction, for the book in question is far better suited to act as a suggestive stimulus to the trained electrician than to serve the purpose of the student. In 1888, Dr. Lodge received the honorary degree of LL. D. from the University of St. Andrews, and was elected a fellow of the Royal Society; he has been a member of the Physical Society since 1875, and for more than a decade has served as an officer of the British Association in various capacities. His ready wit and easy flow of language have given him special prominence in the discussions in which he has taken part, and his clear and lucid way of explaining his ideas has made his scientific papers far more readable than those of many of his fellow countrymen.

Damage by Lightning.

BY N. D. C. HODGES.

I have just looked through the admirable abstract in The Electrical World of May 2 of my paper on lightning protection, read before the Institute of Electrical Engineers, April 21, and hope that its publication may lead to a discussion of the point which I did my best to bring out at the meeting, namely, that I have not found a single case recorded of the failure of a dissipated conductor to protect all parts of a building lying between two horizontal planes passing through its upper and lower ends.

To make my point clear: Let *A* and *B* be two horizontal planes, and *C* a conductor crossing them dissipated by a lightning discharge. I have found no case where any damage happened between the planes *A* and *B*, and no case was cited at the meeting of the Institute. If any such have been recorded I would be glad to hear of them.

47 Lafayette Place, New York City.

Common Sense from Chicago.

Mr. John P. Barrett, Chief of the Department of Electricity of the Columbian Exposition, has made many friends, both in and out of the fraternity, in the struggle he is making for a united electrical exhibit, the value and importance of which he clearly appreciated long ago, as is shown in the excellent paper which he read at the Cape May meeting in August last, when he sounded the keynote for a united exhibit. A paragraph from that paper reads as follows:

"The Exposition should be made just what its name implies, a practical exposition of the progress and advances made in the several branches of the science of electricity, and the exhibits should be so arranged that the various improvements may be seen and appreciated at a glance. Thus will the real object of the Exposition be accomplished and a saving of much valuable time to the visitor be effected. For it is quite probable that fully 50 per cent. of the visitors to the electrical section will go there with the earnest desire to become thoroughly familiar by practical observation and study with all that has been done in some certain industry, either to aid in carrying on a certain line of study or with a view of selecting what they may there conclude is the apparatus best adapted to their needs. In either case, time will be an important and valuable factor, and how to enable each visitor to quickly and understandingly grasp the more important details and points of superiority of any exhibit should be the main object of the respective exhibitors."

The Chicago *Tribune*, the great daily newspaper of the West, has the following excellent editorial, under the heading, "Do not Spoil the Electrical Exhibit," in its issue of Thursday of last week, showing how great an interest has been awakened on all sides:

"Prof. Barrett, Chief of the Department of Electricity of the World's Fair, and the leading electrical firms of the country, say that this special exhibit must not be cut up into two or three departments and scattered through as many buildings. They demand concentration. The Chief of Construction says in reply that he can make no changes in buildings—that the scattered plan of construction on which he is proceeding has been approved by the directory and the National Commission, and that he has no power to alter it.

"But there is the power somewhere, and it ought to be exercised, for the proposed change should be made. The electricians know what they are talking about, and they must be allowed to have their own way. Had they been consulted at the outset so serious a blunder would not have been made. So if the architect has no authority to modify the plans, let the directors and the National Commission do it at once or the Exposition will be damaged.

"The electrical exhibit will be the most valuable and attractive department of the World's Fair, especially to the foreign visitors. This country leads the world in the application of electricity to the uses of life. Minor improvements have been made by other nations, but the United States has kept the lead steadily. The electrical display was one of the most interesting ones at the Paris Exposition, but had the American exhibits been withdrawn it would have been a small affair which would have had but few visitors.

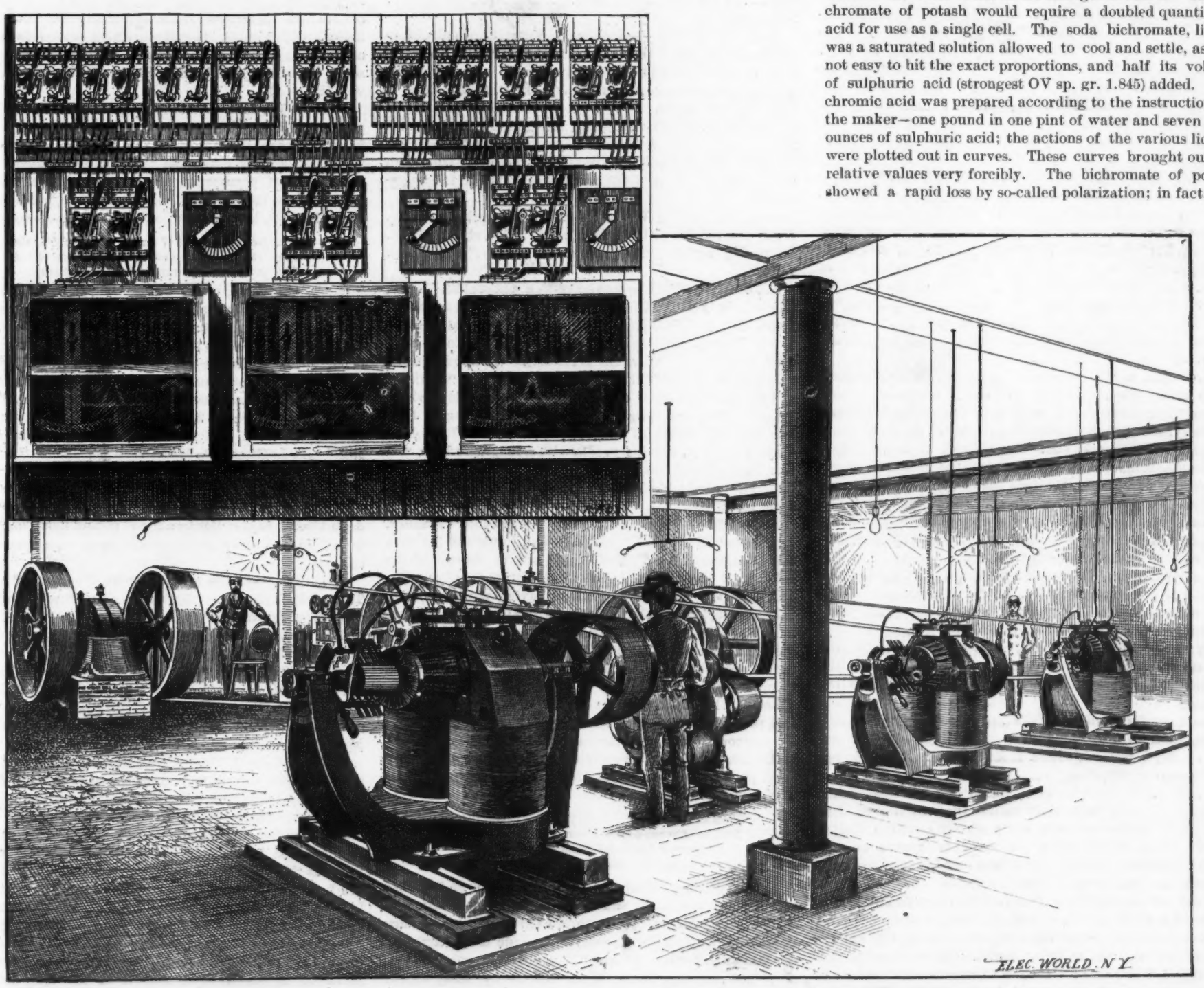
"Since electricity is employed here for such an immense number of objects—for lighting, for power, for mining, for surgical and dental purposes, for talking, for

recording sound, and for many scientific uses—it would be an unpardonable blunder to scatter through three or four buildings what ought to be in one, not merely that the work of competing firms may be better observed, but that the general effect may not be frittered away. It is no wonder that the great exhibitors like Edison protest against having some of their inventions in one place and some in another. They want all that they exhibit to be under one roof, and the visitors, if they could be consulted, would unite in the request.

"Those who are in authority should abandon this scatteration plan before the preparation of estimates and letting of contracts for buildings begin. It will never do to have the great feature of the Exposition whittled down in interest by reason of a faulty arrangement which can be avoided so easily. Prof. Barrett understands his business, and the directors should give him a free hand."

An Isolated Plant in Brooklyn.

The large illustration on this page gives an excellent interior view of the dynamo and engine room of a very complete isolated electric light plant which has just been installed in the Offerman Building, corner of Fulton and Duffield streets, in Brooklyn. As will be seen by the illustration, the electrical equipment consists of three Excelsior dynamos, each having a capacity of 600 incandescent lights and one 30-light arc machine. These are driven by three Ball engines of 65 h. p. each; the middle engine, as shown in the illustration, driving the arc and one of the incandescent machines, while each of the others is belted direct to one incandescent machine. The plant is located in the basement of the building, and the floor of the dynamo room is of cement. This room is about 50 × 75 feet, giving, as will be seen, ample room for attendants while caring for the machines. The plant is fitted also with three of the Excelsior Company's automatic dynamo regulators, and a very complete switchboard, which is shown at the left of the illustration. The switches, ammeters and resistance boxes are all mounted upon one board, are thoroughly insulated and conveniently placed. The entire plant shows that it has been well designed, and the construction work is of an unusually high character.



ISOLATED ELECTRIC LIGHTING PLANT IN THE OFFERMAN BUILDING BROOKLYN.

Electric Welding.

One of the most recent uses for the electric welding process is in the welding of rails. Owing to the difficulty of maintaining rails in crowded and paved streets, it is an advantage to have the rails as long as possible, thereby reducing the number of joints to be cared for. For a year past the Johnson Company, of Johnstown, N. Y., has been experimenting on welding rails up to 110 pounds per yard, and now there is being built for the company by the Thomson Electric Welding Company one of the largest machines ever built for welding. It is to weigh from 20 to 25 tons, and occupy a floor space of 8 by 14 feet.

To give some idea of the comparative cost of electric and the best methods of fire welding, extracts are quoted by the *Railroad Gazette* from a letter written by Messrs. Clarke Chapman & Co., at Gateshead-on-Tyne, England. This firm makes electric and other machinery, and has one electric welder, of limited range, and also does much of the same work by the best of fire methods. The company says: "This is a sample of a week's work taken at random, which we think fairly represents the profit and loss aspect to us of the application of electric welding. There are several other considerations which apply to all possible users: (1) Superiority of welds thus obtained over fire welds; (2) decrease in number of expert smiths; (3) the electric welding process enables articles to be welded in forms unattainable in fire welding, which leads to other improved developments of manufacture."

Detailed figures of the week's work are as follows for the week ending March 18, 1891:

Cost of operating electric welding plant.				*Cost of manufacture of the same product by present forge fire method.*			
1 smith, 53 hours at 33s.	£1	13	0	180 winch stays at 2d.	£1	10	0
1 lad, 53 hours at 14s.	0	14	0	80 connecting rods at 4½d.	1	10	0
1 engineman, 53 hours at 23s.	1	3	0	41 brake straps at 8d.	1	7	4
Cleaning boiler	0	1	6	212 winch handles at 2¼d	1	19	9
Coals—38 cwts.	0	17	0	168 eccentric rods at 2d.	1	8	0
Wear and tear and depreciation	0	12	6	168 piston rods at 2d.	1	8	0
Interest on £1,000	0	19	3	Total	£9	3	1
Glaze wheel grinding	0	0	9		6	1	0
Total	£6	1	0	Saving	£3	2	1

The statement shows a saving by the electric welding method of £3 2s. 1d., or 34 per cent.

High Power Batteries.

Mr. J. T. Sprague, in an article contributed to the *English Mechanic*, gives some interesting and valuable details of experiments made by him with reference to the merits of the more powerful oxidants used in primary batteries. For the purpose of the experiments he constructed a cell with a small porous vessel, which would conveniently hold 400 fluid grains with the carbon plate, so that he could have the conditions exactly alike for each substance. The external consisted of the necessary connections, a large tangent galvanometer, and a copper depositing cell to measure the total work done by the 400 grains of each oxidant.

The following shows the measured resistances of the liquids:

RESISTANCE OF BATTERY LIQUIDS.

	Sp. gr.	Resist.
1. Sulphuric acid 1, water 12, vols.	1.085	60.
2. Sulphate of copper sat. sol	1.172	656.
3. " same + ¼ vol. sulp. acid 1, water 10	1.155	195.5
4. Potash bichromate sat. sol.	1.048	698.
5. " same + $\frac{1}{10}$th vol. H_2SO_4	1.130	70.
6. Soda bichromate sat. sol.	1.422	220.
7. " same + ⅛ vol. H_2SO_4	1.552	80.4
8. Chromic acid, Sullivan's, 1,000 parts to water 1,250	1.353	48.7
9. Chromic acid, 2,250 grs. + 1 fl. oz. H_2SO_4	1.454	57.9
10. Nitric acid	1.375	5.69

The liquids were prepared as usual for battery purposes, in the carbon cell, the acid for acting on the zinc being provided in the outer vessel of the strength of line 1. The bichromate of potash would require a doubled quantity of acid for use as a single cell. The soda bichromate, line 7, was a saturated solution allowed to cool and settle, as it is not easy to hit the exact proportions, and half its volume of sulphuric acid (strongest OV sp. gr. 1.845) added. The chromic acid was prepared according to the instructions of the maker—one pound in one pint of water and seven fluid ounces of sulphuric acid; the actions of the various liquids were plotted out in curves. These curves brought out the relative values very forcibly. The bichromate of potash showed a rapid loss by so-called polarization; in fact, it is hardly possible to measure the early current, it falls so quickly. The very small quantity of work possible justifies the statement that this once-valued salt is now worthless in batteries, compared with others now to be obtained.

Bichromate of soda and chromic acid run each other very closely; but the acid has more staying powers and does more work. Both show a growing current at first.

The curve given by Mr. Bottome's solution shows the great effect produced in the early part of the work by the addition of chlorate of potash to the chromic acid, as well as the increase in the total effect.

The nitric-acid curve, which extended over 30 hours before sinking to the level of the others (which level is really the action of the sulphuric acid on the zinc without any oxidant), shows the vast superiority of this over all other oxidants, so far as the production of current is concerned. The rising curve here is known to be due to lowered resistance (and, it is said, higher E. M. F.), as nitrous acid is generated and dissolved.

The copper voltameter showed the work in ampère-hours of each 400 grains to be:

Nitric acid	16.
Soda bichromate	5.
Potash "	1.7
Chromic acid, Bottone's solution 9	6.4

But the nitric acid had not gone to the level of the rest, as it was stopped at 24 hours; and the bichromate of potash gets credit for too much, as the last six hours of its curve do not really belong to it, but to the zinc and acid.

(*Copyrighted*, 1890.)

Chronological History of Electricity, Galvanism, Magnetism and the Telegraph, from B. C. 2637 to A. D. 1888.—Part I.*

BY P. F. MOTTELAY.

A. D. 1067 to 1148.——Frode (Ari Hinn, or the Wise), Arius Polyhistor (Ari prestrinha Frodi Thorgillsun), Icelandic historian, "than whom there is no higher authority," was the first compiler of the celebrated "Landnama-Bok," which contains a full account of all the early settlers in Iceland, and is doubtless the most complete record of the kind ever made by any nation.

In it he says that at the time Floke Vilgerderson left Rogoland, in Norway, about 868 A. D., for another visit to Gardansholm (Iceland), of which he was the original discoverer, "the seamen had no loadstone (*leiderstein*) in the northern countries," thus showing, according to Prof. Hansteen, that the directive power of the needle and its use in navigation were known in Europe in the eleventh century. Thus is given the first direct intimation of the knowledge of the mariner's compass outside of China. The passage quoted above is by many supposed to be an interpolation, for it is not found in several manuscripts, and it has even been asserted ("Br. Ann.," p. 296) that its origin does not antedate the fourteenth century, thus strengthening the claims of the French in behalf of Guyot de Provins.

See A. D. 1190, also "Landnama-Bok," Kioebenhaven, 1774, T. I., chap. II., par. 7; John Angell, *Magnet. and Elec.*, 1874, p. 10; Lloyd, "Magnetism," p. 101; "Pre-Col. Dis. of Am.," De Costa, pp. xxiii. and 11; "Bull. de Géog.," 1858, p. 177; *Good Words*, 1874, p. 70; Klaproth, "Boussole," p. 40; Hansteen, "Inquiries Concerning the Magn. of the Earth" and *Magazin for Naturvidenskaberne Christiana*, I., 2.

A. D. 1111 to 1117.——Keou-tsoungchy, Chinese philosopher and writer, gives, in the medical natural history called "Pen-thsao-yan-i," written by him under the Soung dynasty, the earliest description of a water compass found in any Chinese work, viz.: "The magnet is covered over with little bristles slightly red, and its superficies is rough. It attracts iron and unites itself with it; and for this reason it is commonly called the stone which licks up iron. When an iron point is rubbed upon the magnet it acquires the property of pointing to the south, yet it declines always to the east, and is not perfectly true to the south. . . . If the needle be passed through a wick or a small tube of thin reed, and placed upon water, it will indicate the south, but with a continual inclination toward the point *ping*, that is to say, East five-sixths South."

In the "Mung-khi-py-than," also composed under the Soung dynasty, it is stated that fortune-tellers rub the needle with the loadstone in order to make it indicate the south.

See *Comptes Rendus*, T. XIX., p. 365; *Am. Jour. Sc. and Arts*, 1841, XL., p. 248; Davis, "The Chinese," 1844, vol. III., p. 13; Becquerel, "Elec. et Mag.," p. 58; Klaproth, pp. 67–69 and 95; "Cosmos," vol. II., 656.

A. D. 1160.——Eustathius, Archbishop of Tessalonica, relates in the Commentary on the Iliad of Homer, that Walimer, father of Theodoric and King of the Goths, used to emit sparks from his body; also that a certain philosopher observed sparks occasionally issuing from his chest accompanied with a crackling noise.

Leithead tells us that streams of fire came from the hair of Servius Tullius, a Roman King, during sleep, when he was about seven years of age (Dyonisius, "Antiq. Rom.," lib. IV.; Pliny, "Hist. Nat.," lib. II., cap. 37); that Cardan alludes to the hair of a certain Carmelite monk emitting sparks whenever it was rubbed backward (lib. VIII., "De Rerum Variet," cap. XLIII.); that Father Faber, in his "Palladium Chemicum," speaks of a young woman whose hair emitted sparks while being combed, and also refers to allusions made in the same line by Bartholinus, "De Luce Animalium," Lugd., 1647, p. 121; Ezekiel di Castro, "De Igne Lambente"; Hemmer, *Trans. Elec. Soc. Mannheim*, vol. VI., or *Phil. Trans.*, vol. V., pp. 1 and 40.

See Eustath in Iliad, E., p. 515, Ed. Rom.; "Ency. Brit.," 1855, VIII., p. 571; Priestley, "History of Electricity," London, 1775, pp. 128, 129; *Phil. Trans.*, vol. X., pp. 278, 343, 344, 357.

A. D. 1190——Guyot de Provins, minstrel at the Court of the Emperor Frederick I. (Barbarossa), gives the first French mention of the water compass in a manuscript "politico-satirical" poem entitled "La Bible," to be found in the French Royal Library. It is therein said that sailors were at that time in the habit of rubbing needles upon the ugly brown stone called *marinière*, "to which iron adheres of its own accord," and that, as soon as placed afloat upon a small piece of straw in the water, the needles would point to the North. The entire passage alluding to the compass has been copied by D. A. Azuni, member of the Turin Academy of Sciences, from the original manuscript, and is given entire, with the French translation, at page 137 of his "Dissertation, etc.," second edition, Paris, 1809:

" . . . Par la vertu de la marinière,
Une pierre laide et brumière,
Ou li fers volontiers se joint, . . ."

The passage is also given by Klaproth at page 41 and by Venanson at page 72 of their respective works already cited.

Sonnini (C. S.), in Buffon "Minéraux," vol. XV., p. 100, says that Azuni has successfully established the claims of France to the first use of the mariner's compass. Other writers, who follow in their order, will doubtless show to the satisfaction of the reader that, as the Arabs possessed it at the same time, they must have received it from the Chinese, and therefore transmitted it to the Franks during the first Crusades, as stated by Davis ("The Chinese," vol. III., p. 12), and by Klaproth in his "Lettre à M. de Humboldt," Paris, 1834, pp. 64-66.

See Becquerel, "Traité d'Elect. et de Mag.," vol. I., p. 70; R. M. Ferguson, "Electricity," 1867, p. 43; "Bulletin de Géographie," 1858, p. 177; Barbazan, "Fabliaux," vol. II., p. 328; Becquerel, "Résumé," chap. III.; "Cosmos," vol. II., p. 626-629; *Amer. Jour. Sc. and Arts*, vol. XL., p. 243.

A. D. 1204 to 1215.——Jacobus de Vitry, Cardinal Bishop of Ptolemais, one of the Crusaders, thus speaks of the compass in his "Historiæ Hierosolimitanæ," cap. 89: "The magnet (*diamant*, as shown under the B. C. 321 date) is found in the Indies. . . . It attracts iron through a secret virtue; after a needle has touched the loadstone, it always turns toward the North Star, which latter is as the world's axis and is immobile, while the other stars turn around it; that is why the compass is so useful to navigators."

See Azuni, p. 140; Venanson, p. 77; Klaproth, pp. 14, 43, 44; *Pogg.*, vol. II., p. 1,184; Becquerel, "Elec. et. Mag.," vol. I., p. 70; Knight, "Mechanical Dictionary," vol. II., p. 1,397.

A. D. 1207.——Neckham (Alexander), Abbot of St. Mary's, alludes, in his "De Utensilibus," to a needle carried on board ship, which, being placed upon a pivot and allowed to take its own position of repose, "showed mariners their course when the Polar Star is hidden." In another work "De Naturis Rerum" (lib. II., cap. 89), he writes: "Mariners at sea, when, through cloudy weather in the day, which hides the sun, or through the darkness of the night they lose the knowledge of the quarter of the world to which they are sailing, touch a needle with a magnet which will turn around until, on its motion ceasing, its point will be directed toward the North." (Chappell, *Nature*, No. 346, June 15, 1876.)

A. D. 1250.——Vincent de Beauvais, another Crusader, writes his "Mirror of Nature" for Saint Louis and his consort Marguerite de Provence, and speaks therein of the polarity of the needle ("Speculi Naturalis," vol. II., lib. IX., cap. 19). He cites Aristotle as having written a book, "De Lapide," containing a notice of the use of the magnet in navigation, but none of Aristotle's works appear to have the passage given. Cabæus and others rather judge that book to be the work of some Arabic writer (Thomas Creech, "Lucretius").

Le sieur Petrus Peregrinus de Marcourt alludes clearly to the polarity of the needle in an epistle, "Ad Sigerium de Foneaucourt militem de Magnete," written toward the end of the thirteenth century, and the magnet is at about the same period referred to in the following poem of the minstrel Gauthier d'Espinois:

"Tous autresi (ainsi) comme l'aimant déçoit (détourne)
L'aiguilette par force de vertu
A ma dame tot le mont (monde) retennue
Qui sa beauté connoit et aperçoit."

Vincent de Beauvais applies the terms *zohron* and *aphron* (not *afon*) to the south and north ends of the needle, and Klaproth ("Boussole," pp. 49 to 51) says these words are Arabian, notwithstanding assertions made to the contrary by Martin Lipenius, in his "Navigatio Salomonis Oph. Ill.," 1660, 12, cap. V., sec. 3, as well as by many others who have written upon the compass. See Sonnini, in Buffon, "Minéraux," VIII., p. 76; "Cosmos," vol. II., p. 620; Azuni, pp. 41, 42 and 44; Klaproth, p. 13; "History Philosophically Illustrated," London, 1849, vol. I., p. 179, note.

A. D. 1254.——Albertus Magnus, of the family of the Counts of Bollstädt, one of the most prominent philosophers and theologians of the middle ages, likewise alludes to the "De Lapide" and to the Arabic terms *zohron* and *aphron*, giving to these words, however, a wrong interpretation.

He is said to have constructed, after 30 years of experimentation, a curious machine which sent forth distinct vocal sounds, at which the very learned scholastic philosopher Saint Thomas Aquinas ("Angel of the Schools") was so much terrified that he struck the contrivance with his stick and broke it. Bishop Wilkins (see A. D. 1707) alludes to an image constructed by Albertus Magnus, as well as to a brazen head devised by Friar Bacon, which could be made to utter certain words.

Incidentally, it may be mentioned that Wolfgang von Kempelen, Aulic Counsellor to the Royal Chamber of the Domains of the Emperor of Germany, after witnessing some magnetic games shown to the Empress Maria Theresa at Vienna, constructed, during the year 1778, a speaking machine which "gave sounds as of a child three or four years of age, uttering distinct syllables and words." See Sonnini, Buffon, "Minéraux," VIII., p. 76; Enfield, "History of Philosophy," book VII., chap. 3; "Cosmos," II., pp. 617–619; Quetif and Echard, "Scriptor. Ord. Predicat.," vol. I., p. 171; Brande. "Manual," 1848, vol. I., p. 8.

A. D. 1254.——Bacon (Roger), sometimes called Friar Bacon, a Franciscan monk of Ilchester, who devoted himself to the study of science at Oxford and Paris, and "whose deep penetration into the mysteries of nature justly entitled him to the appellation of The Wonderful Doctor," dwells upon the mariner's compass as a *miraculum in parte notum*, in his "Op. Min.," p. 383.

De Humboldt says that Roger Bacon, Albertus Magnus and the Arabian philosophers Avicenna (Ibn-Sina) and Averroes (Ibn-Roshd) "passed for the representatives of all the knowledge of their time." See Enfield, book VII., chap. 3; "Cosmos," vol. II., pp. 615, 617, 619.

A. D. 1260.——Brunetto Latini, "maestro del divino poeta Dante," celebrated Florentine encyclopædist, composes his "Tesoro," rewritten in French ("Livres dou Trésor"), wherein he speaks clearly of the compass as at some time likely to be useful at sea. But he adds: "No master mariner dares to use it, lest he should fall under the supposition of being a magician; nor would even the sailors venture themselves out to sea under his command if he took with him an instrument which carries so great an appearance of being constructed under the influence of some infernal spirit." See Davis, "The Chinese," 1844, vol. III., p. 11.

A. D. 1265 to 1321.——Dante (Alighieri), illustrious Italian poet, regarded as the greatest poetical genius that flourished between the Augustan and Elizabethan ages, composed, during his exile, the "Divina Commedia," which was the first poem written in the Italian language. In canto XII., verses 28 to 30, of his "Paradiso," translated by Dr. Plumptre, he thus alludes to the mariner's compass:

"Then from the heart of one of those new lights
There came a voice which made me turn to see
E'en as the star the needle's course incites."

Guido Guinicelli, priest and scholar, and whom Dante considered not only the greatest of living Bolognese poets, but his master in poetry (note, Purg.," XXVI., vol. I., p. 327, verse 92), refers to the nautical compass in nearly the same terms as Dante ("Rime Ant.," p. 295). He adds: "The mountains of loadstone give the virtue to the air of attracting iron, but, because it (the loadstone) is far off, (it) wishes to have the help of a similar stone to make it (the virtue) work, and to direct the needle toward the star." (P. L. Ginguené, Hist. Lit. d'Italie," vol. I., p. 413.)

The "Paradiso," translated by A. J. Butler, London, 1885, canto XII., verse 29, reads:

"Si mosse voce, che l'ago (needle) alla stella" and Fazio degli Uberti, in the "Dittamondo" (about 1360), has "Quel grau disio, che mi traeva addietro, come ago a calamita" (III., 2).

A. D. 1266.——It is shown by Th. Torffaeus (Latin for Thormodr Torfason, an Icelandic scholar who published "Historia Rerum Norvegicarum," Hafniae 1711, IV., c. 4, p. 345), that at this date the northern nations were acquainted with the mariner's compass. In the history of Norway alluded to he mentions the fact that the poem of the Icelandic historian Jarl Sturla (Snorri Sturlason), written in 1213, on the death of the Swedish Count Byerges, was rewarded with a box containing a mariner's compass.

A. D. 1269.——Adsiger (Peter) has had attributed to him a letter under this date containing the earliest reliable notice of the variation or declination of the magnetic needle, and from which is extracted the following: "Take notice that the magnet, as well as the needle that has been touched by it, does not point exactly to the poles, but that the part of it which is reckoned to point to the south declines a little to the west, and that the part which looks toward the north inclines as much to the east. The exact quantity of this declination I have ascertained, after numerous experiments, to be *five degrees*. However, this declination is no obstacle to our guidance, because we make the needle itself decline from the true south by nearly one point and a half toward the west. A point, then, contains five degrees."

The letter said to contain the above is quoted by Cavallo, in the supplement to the second edition of his work on "Magnetism," as being in the Leyden University, but this is denied by De Humboldt, who says the passage "exists as an interpolation in a copy which is to be found in the Library of Paris."

See Walker, "Magnetism, etc.," 1866, p. 6; "Examen Critique," De Humboldt, vol. III., p. 31; Wenckebach, quoted by Lamont, "Handbuch des Magnetismus," p. 449; "Enc. Met.," III., 737, and, for the means of determining the variation or declination, "Eng. Cycl. Art and Sc., vol. VIII., p. 160; Dr. Hutton's "Phil. and Math. Dictionary."

A. D. 1270.——Riccioli (Giovanni Battista), an Italian astronomer, member of the Society of Jesuits, asserts that at this period, under the reign of Saint Louis (1226–1270), French navigators were already using the magnetic needle, which they kept floating in a small vase of water, and which was supported by two tubes to prevent its falling to the bottom.

See Davis, "The Chinese," vol. III., p. 11; Venanson, pp. 70, 71; Klaproth, p. 54; Becquerel, "Résumé," p. 59.

*Continued from The Electrical World, May 2, 1891.

Alternating Current Electric Motors.—I.

BY DR. LOUIS DUNCAN, JOHNS HOPKINS UNIVERSITY.

The electric transmission of power presents to-day two very distinct problems: distribution in comparatively small units from central stations, and isolated or special transmissions. For the first, alternating current motors are used hardly at all, but in special cases and especially for long distance transmissions in large units the alternating current presents many advantages, and will come into extended use.

It is difficult to write about alternating current electric motors. There are no experimental data available, in fact very little has been obtained. Different inventors have worked with their own machines, but I have never seen one fully described, and the tests published have been mere statements of results. It is particularly embarrassing to an outsider to attempt to criticise a machine of which he has no knowledge excepting that obtained from a patent specification, or a conventional description; but if the inventor is irritated into refuting the outsider by facts and data, a commendable object has been achieved.

Alternating current electric motors may be divided into two broad types. In the first there is but one transformation in the machine, that of the electric energy of the armature current into the mechanical energy of the armature's rotation. In the second there are two transformations in the machine: one is a transfer of electrical energy from the main circuit into the electrical energy of the armature current; the other of the electric energy of the armature current into mechanical energy. The first type is best exemplified by the ordinary alternating dynamo reversed; the second type by Tesla's or Thomson's motors.

In considering these transformations we must keep clearly in mind the fact that when electrical energy is changed into any other form the amount transferred from a circuit is equal to $e\,i$, where i is the current flowing in the circuit and e is the counter electromotive force, or fall of potential due to the transfer. This is true, of course, whether the transformation is into heat, or mechanical energy, or the energy of the magnetic field, or into any other possible form.

To take up the first type of motor—that in which the current from the main circuit flows in the motor armature—we will find a number of forms patented or described. The simplest and most obvious is the ordinary alternating dynamo reversed. The theory of this type has been discussed more or less fully by Dr. Hopkinson, Mr. Mordey, Mr. Swinburne, and others, but as no one of the writers on the subject agrees with any of the rest, and as the views of some of them must differ very widely from what actually happens, we can hardly congratulate ourselves on having been taught very much about the subject.

There seems to be so much confusion about the matter of reversed alternating dynamos that a very brief statement of the problem may not be out of place.

In 1884, Dr. John Hopkinson, in a paper before the Institution of Electrical Engineers (London), showed theoretically that two alternating machines could not be run on series unless they were rigidly connected—as they would tend to control one another, so their electromotive forces would be opposed. He also showed that two such machines could be run in parallel, and that one could run another as a motor, and he gave the equations for the work done on such a motor connected between a pair of mains carrying alternating currents.

Suppose we have an alternating machine, and after starting it to its normal speed join it to mains, the period

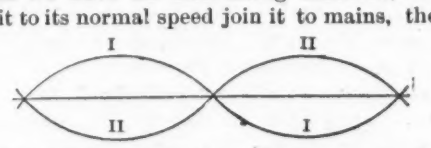


FIG. 1.—CURVES OF ALTERNATOR WHEN IT IS DOING NO WORK.

of the E. M. F. of our machine being that of the E. M. F. applied to the main. If our alternator is doing no mechanical work—we will suppose for a moment that there are no losses—the condition of affairs will be given by the curves in Fig. 1, where I is the E. M. F. of the mains, II that of the motor, the latter lagging 180 degrees behind the former, so that if the two electromotive forces are equal there will be no flow of current. Suppose that a load be put on the motor, it will tend to slow down and still further increase the lag of its E. M. F. There will now be a current due to the difference of the E. M. Fs. as shown in Fig. 2. Here I is the line E. M. F.; II the motor E. M. F.; III the effective E. M. F. in the motor circuit. If there is no self-induction the armature current will follow III, and in this case the work done on the motor armature—which is the product of the current by II—is not negative; that is, the motor is not transforming electrical into mechanical energy. If, however, there is self-induction in the armature circuit the current will lag behind the effective E. M. F. III, and take up some position.

Now the product of IV by II is negative and the motor does mechanical work. It would seem that self-induction is necessary for the successful working of such a machine. If we increase the load on the motor gradually, the lag of e (the motor E. M. F.) will gradually increase until $\tan. = \frac{2\pi}{T}\frac{L}{R} - L$, being the self-induction and R the resistance of the armature circuit when the output is a maximum. If we still further increase the load the motor will stop. We may represent the state of things by a curve in which the loads are ordinates and the corresponding lags of e are abscissæ. This curve may really be called the "characteristic" of an alternator. After the maximum point a is reached a further increase of φ will correspond to a decrease in the power of doing work, and the motor stops.

The equations for the output of a motor on an alternating circuit have been worked out, as has the maximum value of the work in different cases. For instance, Messrs. Wilkes and Hutchinson find that the maximum output of a motor is independent of its self-induction and is equal to $\frac{E^2}{8R}$; provided $\frac{2\pi}{T}L = R$, $\tan.\varphi = \frac{2\pi}{T}\frac{L}{R}$ and $l_0 = \frac{E_0}{2\sqrt{1+\frac{p^2L^2}{R^2}}}$, where ε_0 and E_0 are respectively the maxima of the motor and line E. M. Fs. and $p = \frac{2\pi}{T}$. That is, if the self-induction and E. M. F. of the motor be given the proper values, the output of an alternating motor is equal to that of a continuous current motor supplied from a source with an equal effective E. M. F. Now a continuous motor can—from heating and efficiency considerations—be worked at only a small fraction of its

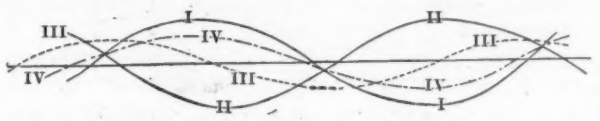


FIG. 2.—CURVES OF ALTERNATOR WHEN LOADED.

maximum possible output, so it would seem that an alternating motor with a load equal to that of a corresponding continuous machine would be so far from its maximum output that there would be very little danger of its ever falling behind the point a and stopping. Yet it would seem that they do stop when a load is applied, so evidently the motors are badly designed or the above explanation is not entirely true, and the fact is that both of these suppositions are correct.

The above very brief sketch gives about the condition of things until a paper by Mr. Mordey was read before the English Institute of Electric Engineers. In treating the subjecting of alternating current working, Mr. Mordey took the ground that an alternator would synchronize best and run best as a motor if its resistance and self-induction were as small as possible. He gave some excellent results, unfortunately with very little data attached, obtained with a machine which he seemed to think had no self-induction. But Prof. Ayrton had the self-induction measured and the value was .03; the resistance, from a remark in Mr. Mordey's paper, I estimate at 5.0 ohms; T was $\frac{1}{100}$ sec. The best value of the self-induction, from $\frac{2\pi}{T}L = R$ would have been roughly .008; so instead of having no self-induction the machine had considerably too much. The maximum output of the machine described by Mr. Mordey connected to mains of an E. M. F. equal to its own would be, roughly $(e = 2{,}000\ R = 5.0\ L = .03)\ \frac{E^2}{10R} =$ 80,000 watts, over 100 h. p., while the machine was only intended to and did run at 50 h. p. The performance is not surprising.

In fact, no experiments have been brought forward that clearly disprove Dr. Hopkinson's theory, although the difficulties experienced in practice show that it has not been followed or that it is wrong. For myself, I consider it fairly satisfactory for a number of machines, although it confessedly fails to take into account changes in coefficients of self-induction, armature reactions, etc., for the special case of a load very gradually applied. There are machines in which the armature reactions are not great and the value of L is reasonably constant, and these should fit the theory quite well.

When the load is suddenly applied, however—and this is very often the case in practical working—the condition of affairs is different, and is not taken into account in the ordinary theory. A continuous current machine may slow down a turn or so while it is taking its load without any harm being done; but an alternating motor can only while its load is being taken through an angle $\varphi_0 - \varphi$, the difference between the position when the load is applied and the position of maximum output. If the machinery to be driven has any considerable inertia the motor will very probably stop unless some friction clutch arrangement or other device which will gradually start the machinery is used. Between the throwing on of the driven machinery and the time when it reaches its normal speed, the motor must supply enough energy not only to overcome the resistance of the machine during the interval, but to store up in it the energy due to its inertia and velocity. To do this the inertia of the motor can only be called slightly into play, for it is essential that its speed should decrease very little and then but for an instant.

The condition of affairs for a half period in the motor is roughly this: On the application of the load, the armature or field slows down; this causes a reduction of the motor E. M. F. for two reasons: the speed is decreased, and the reaction of the armature current weakens the field both because of the changed position of the coils and the increased strength of the current. The period of the motor E. M. F. is also increased, and the increase is not necessarily small, for, although the armature lags through a small angle, yet it is in a very short time. The effect on the effective E. M. F. in the armature circuit is twofold: its value is very rapidly increased, due to the decrease of the counter E. M. F. and the shifting of phase of the latter with respect to the line E. M. F., while its period is for an instant changed and its form will differ considerably from that of a sine curve. The rush of current corresponding to this effective E. M. F. will be opposed by the resistance and self-induction of the armature circuit, *but the proportionate effect of the latter will be greater than under normal circumstances*, for our current curve is for an instant *sharper* than an ordinary sine curve. It would be outside of our mathematics to combine this current with the motor E. M. F., since they have for the instant different periods; but we may say in a general way that a smaller value of the self-induction than is given by the ordinary equations is required to resist the stopping effect of suddenly applied loads. We have seen that a well-designed machine working at a practical load is within the maximum load limit for steady or slowly applied loads. The danger of stopping is when a load is suddenly applied, and this is best resisted when the self-induction of the motor is low. I imagine it will be hard in practice to make it as low as we could wish.

I have spoken of the state of affairs for a half period. It is evident that if the load is more slowly applied the shifting of the motor curve will occupy a number of periods and our current curve will not be so sharp. The lag will approach its maximum value and then decrease again to a position corresponding to the work to be done. But, whatever the special case may be, Mr. Mordey worked in the right direction when he opposed the idea which seemed to be prevalent that a great deal of self-induction was necessary for alternating motors.

Lately Mr. Swinburne read a paper on the subject of alternating currents, in which he accounts for all the phenomena which he believes to occur by "armature reactions." He has at times complained that Dr. Hopkinson neglected armature reactions or included them in his term "self-induction." Mr. Swinburne retaliates by including self-induction and other effects in "armature reactions."

Those who have read Mr. Swinburne's paper have noticed that he treats the running of alternators in parallel or as motors under two headings: "Running according to the orthodox hypothesis," and "Running according to the armature reaction theory." He extends the work already done under the first heading by finding the increment of power corresponding to a small increment of current, and then finding "the value of L which makes the result a maximum." L unfortunately disappears before its value can be found, and really the results could be of no value, for we have seen that just at the moment that Mr. Swinburne uses the equations—when the load is changed—these equations do not in any way hold. As far as the second heading goes, Mr. Swinburne abandons everything but armature reactions. The effect of the armature current, provided the alternations are rapid enough, is twofold. It causes "the current to lag relatively to the position of the field magnets, and then lessens the pressure as a whole." The first of these does not affect the steady working of the machine, for it is the relative position of the current with respect to the resultant field, not of the poles, that is of importance; the sec-

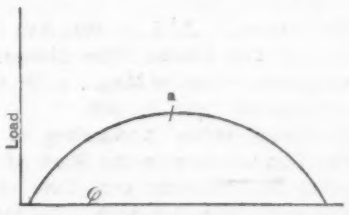


FIG. 3.—CURVE SHOWING EFFECT OF INCREASING THE LOAD.

ond increases, within limits, the output of the machine for a given lag. But the result is not equivalent to a self-induction. On this theory a machine with a saturated field would not work, while in reality—if we may believe statements on the matter—these machines work very well.

In England there seem, then, to be several opinions with respect to the best value of the self-induction for reversed alternating dynamos. Dr. Hopkinson holds that $\frac{2\pi}{T}L$ should be equal to R; Mr. Kapp, Prof. Forbes and others seem to hold that the self-induction should be large (they do not seem wedded to any especial value); Mr. Mordey holds that it should be zero, if possible; Mr. Swinburne seems to have lost L altogether through differentiation, and is, therefore, presumably indifferent as to its value. For myself, I believe that L should have a value large enough to make the maximum output of the motor greater than the normal output, but should be less than the value given by $\frac{2\pi}{T}L = R$. That the resistance should be as small as possible goes without saying, and it is equally evident that if the motor is to be run on light loads its E. M. F. should be approximately equal to that of the line.

There are some things that are attractive in this type of motor. The iron in the field magnets is not reversed as in many other types; the efficiency should approximate to that of an alternating dynamo, which is quite satisfactory, and no change is required in an ordinary transformer system of distribution. The practical difficulties lie in the

fact that the motor must be brought to almost its normal speed by some means outside of the alternating current; and a continuous or redressed current must be supplied to the fields. In a paper read early in 1888, the author proposed to remedy these troubles by running with the alternating circuit an auxiliary continuous current circuit to excite the fields and start the motors. The latter function was performed by commutating the armature coils until the motor had attained normal speed, when the commutator was thrown out and the machine ran as an alternating motor. It was also proposed to use a friction pulley to prevent a suddenly applied load stopping the machine. Most of these suggestions have since been patented (not by the author), and some results may follow, although they do not seem to have been applied. They seem to me practical enough.

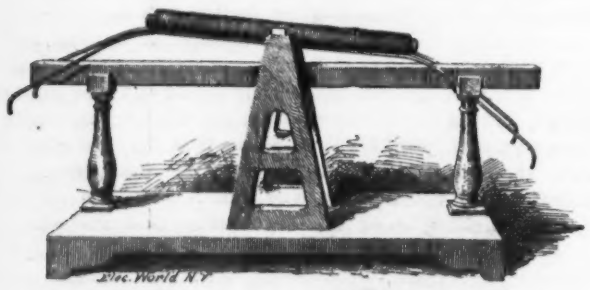
Henry's Electric Motor Constructed in 1831.

BY J. ELFRETH WATKINS.

One of the most interesting objects displayed in the loan collection of mechanical relics, etc., exhibited in the lecture hall of the U. S. National Museum at Washington during the patent centennial celebration was the original electro-magnetic engine designed by Joseph Henry in 1831, and constructed with his own hands. This machine, simple as it is, is one of the earliest applications of magneto-electricity to the production of power. Henry calls it "Reciprocating motion produced by magnetic attraction and repulsion." In July, 1831, writing to the editor of *Silliman's Journal*, he says:

"I have lately succeeded in producing motion in a little machine by a power, which, I believe, has never before been applied in mechanics—by magnetic attraction and repulsion.

"Not much importance, however, is attached to the invention, since the article, in its present state, can only be considered a philosophical toy, although in the discovery and invention it is not impossible that the same principle, or some modification of it on a more extended scale, may hereafter be applied to some useful purpose. But without reference to its practical utility, and only viewed as a new effect produced by one of the most mysterious agents of



Henry's Electric Motor Constructed in 1831.

nature, you will not, perhaps, think the following account of it unworthy of a place in the *Journal of Science*.

"It is well known that an attractive or repulsive force is exerted between two magnets, according as poles of different names, or poles of the same name, are presented to each other.

"In order to understand how this principle can be applied to produce a reciprocating motion, let us suppose a bar magnet to be supported horizontally on an axis passing through the centre of gravity, in precisely the same manner as a dipping needle is poised; and suppose two other magnets to be placed perpendicularly, one under each pole of the horizontal magnet, and a little below it, with their north poles uppermost; then it is evident that the south pole of the horizontal magnet will be attracted by the north pole of one of the perpendicular magnets, and its north pole repelled by the north pole of the other; in this state it will remain at rest, but if by any means we reverse the polarity of the horizontal magnet, its position will be changed and the extremity, which was before attracted, will now be repelled; if the polarity be again reversed, the position will again be changed, and so on indefinitely. To produce, therefore, a continued vibration, it is only necessary to introduce into this arrangement some means by which the polarity of the horizontal magnet can be instantly changed, and that, too, by a cause which shall be put in operation by the motion of the magnet itself; how this can be effected will not be difficult to conceive, when I mention that instead of a permanent steel magnet in the movable part of the apparatus, a soft iron galvanic magnet is used.

"The motion, here described, is entirely distinct from that produced by the electromagnetic combination of wires and magnets; it results directly from the mechanical action of ordinary magnetism, galvanism being only introduced for the purpose of changing the poles."

At the end of sixty years the same principle that led the great physicist (who is known to the world as a discoverer rather than an inventor) to make this "little machine" is used in constructing the electrical devices which may properly be classed among the mechanical triumphs of the century of invention which have been indelibly recorded is the annals of our history by the recent patent centennial celebration.

Graphic Method for Analyzing Losses in Armature Cores, etc.*

BY R. H. HOUSMAN.

It has long been known that the losses in the armature core of a continuous current dynamo may be accurately measured by running it as a motor without load, and noting the power absorbed. It was also shown by Mr. Mordey some little time ago that, by plotting the losses, so measured, at different speeds, those which are proportional to the square of the speed (Foucault currents) may be separated from those which are directly proportional to the speed (hysteresis) by a mathematical process; but this process debars the method from general use.

It is, however, possible, by a simple graphical construction, to separate the different losses without any recourse

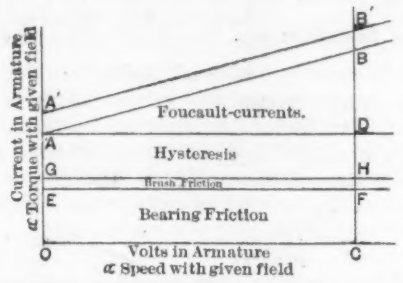


Fig. 1.—Electrical Diagram.

to mathematics at all. The method is as follows: Measure the current required to run the armature as a motor light with different volts on the armature, the magnets being separately excited so as to keep the field constant. On plotting the results as a curve, as in $A\ B$, Fig. 1, it will be found that the curve is a perfectly straight line, cutting the axis of current at some distance from the origin.

Now, taking any point B on the curve, and drawing $B\ C$ parallel to $A\ O$, it is evident that the total loss is represented by the product $O\ C \times C\ B$.

Next draw $A\ D$ parallel to $O\ C$; this divides the area representing the total loss into two parts, one of which, $O\ D$, is proportional to $O\ C$, and the other, $A\ D \times D\ B$, is proportional to the square of $O\ C$, since $B\ D$ is proportional to $A\ D$, which $= O\ C$. The first of these areas represents the waste of energy per second due to hysteresis and friction combined, while the second gives the loss due to Foucault currents. It must be noticed that it is the product of the co-ordinates of any point on $A\ B$, which represents the waste and not the area of the figure $A\ O\ C\ B$. In this respect the diagram resembles the characteristic of a dynamo rather than the diagram of a steam engine.

Friction of bearings and brushes must be determined separately by coupling direct to a similar motor and observing the increase of current required to drive with the fields unexcited. This will be constant at all speeds.

From this experiment draw $O\ E$ equal to the current observed as required for friction alone; then $E\ F$, being drawn parallel to $O\ C$, the rectangle $O\ F$ represents loss by bearing friction. By a simple experiment the loss by brush friction may be determined and $G\ H$ drawn, so that $E\ H$ represents the loss from this cause. The remaining rectangle, $G\ D$, will then show the loss due to hysteresis. It will be readily understood that only the losses represented by $G\ H \times H\ B$ (Foucault currents + hysteresis) appear as heat in the armature.

A second set of experiments may be made with a different strength of field, and plotted in a curve, $A'\ B'$, which is in general parallel to $A\ B$, showing that Foucault currents are constant for given volts. $A'\ B'$ will be above or below $A\ B$, according as the change of field intensity has

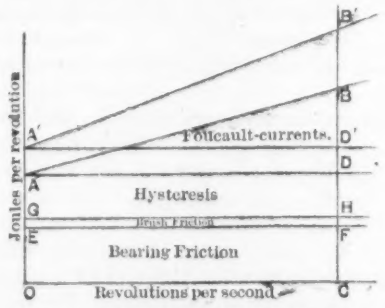


Fig. 2.—Mechanical Diagram.

increased or diminished, the sum of the losses due to hysteresis and friction, these two varying inversely, though not in simple inverse ratio.

At a certain intensity the total losses for given volts will be a minimum; this in practice seems generally to occur between 15,000 and 16,000 lines per square centimetre in the iron of the armature, but the exact figure depends on whether friction is large or small. In machines with little friction the best intensity may be much lower. There is a curious point about the Foucault currents at high intensities (18,000 or 20,000); they show a decided tendency to *increase*, the slope of the curve $A\ B$ becoming much steeper. This is probably due to the increased stray field in the shaft and flanges at the ends of the armature, which being solid metal may have large currents in them when the field through them reaches 200 to 300 lines per square centimetre.

In Fig. 1 all the quantities have been measured electrically; hence it may be called the electrical curve to distinguish it from another diagram which may be derived from it, in which the quantities are measured in mechanical units. The electrical diagram has the disadvantage that for each intensity of field a separate friction line has to be drawn, which makes it difficult to distinguish how much of the whole loss is electrical and how much frictional, when there is more than one curve drawn on the same diagram. This difficulty is obviated by plotting revolutions per second instead of volts along the horizontal axis, and work per revolution in joules instead of current along the vertical axis. It will be noticed that the product of these two is expressed in watts (or work per second), as before, but it only requires an alteration of scale to make the co-ordinates revolutions per minute and foot-pounds per revolution respectively, in which case the product ÷ 33,000 gives horse power.

In this diagram the same friction line holds good for all intensities, and the frictional and electrical losses are separated by the line $G\ H$ (Fig. 2). It will also be seen that the quantities $G\ A$ and $G\ A'$ represent the losses by hysteresis, in joules per cycle, at the two intensities, for which $A\ B$ and $A'\ B'$ are drawn, respectively. The loss per cubic centimetre from this cause is always found to be much greater than that generally given.

* From *The Electrician*, London.

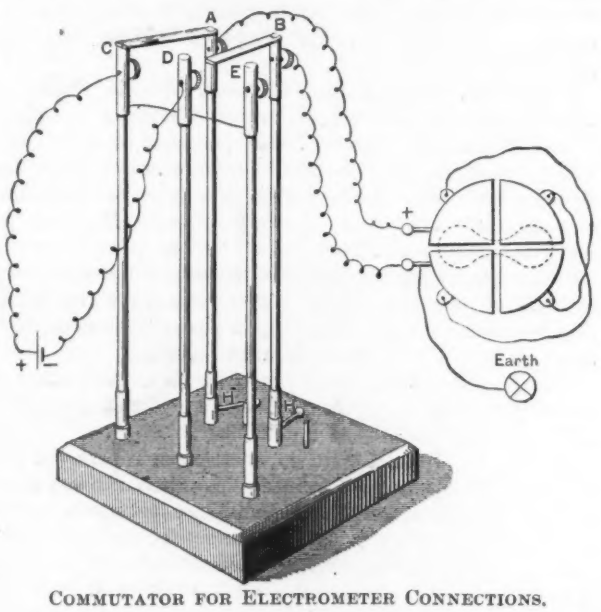
An Electrostatic Commutator.*

BY ROLLO APPLEYARD.

The electrostatic commutator here shown is a simple apparatus, of small capacity and high insulation, for effecting all the ordinary connecting operations with electrometers.

It consists of five insulating rods, three of which, C, D, E, are fixed; A and B are fitted into brass sockets in the baseboard with spring washers, so as to be capable of turning about a vertical axis by handles, H.

At the top of each fixed rod is a binding screw, tipped



Commutator for Electrometer Connections.

with platinum, and having a slightly convex surface of contact.

The rods A, B carry contact springs with corresponding hollows at their rubbing ends, so that when the handle is moved the spring slides on and drops into place easily.

The screws C and E are connected permanently together by a wire.

A and B are the quadrant terminals; D, and either C or E, are for the test wires. This method of connecting prevents all possible chance of short-circuiting a cell under test. By sliding the springs on to C and D the quadrant in connection with A becomes +, and that jointed to B is —. We may reverse by sliding the springs to D and E respectively.

The electrometer quadrants are connected together by joining A to C and B to E—in which position the springs should always be left after a test.

In intermediate positions the quadrants are completely insulated. When very high insulation is required, some dessicating arrangement may be employed. With a slight modification of the handles, a place might be found for this commutator inside the electrometer case itself, the handles being entirely outside, below the base.

* From *The Electrician*, London.

Ganz Alternate Current Motors.

In Fiume, Austria, four 10 h. p. Ganz alternate-current motors are applied to working passenger elevators, and two others will shortly be added. The International Electric Company has a central station in Fiume capable of supplying 80,000 watts, of which 30,000 watts are used for transmission of power and 10,000 watts for lighting the Fiume railway station. In the finished station there will be more than 100 h. p. for motive power, besides current for lighting the docks and all the warehouses alongside. The Ganz motors are of 10 h. p., very similar to their type "A" alternate-current dynamos. The current is brought in parallel at 2,000 volts, and is transformed down to 50 volts for the motors, which, moreover, are all connected in par-

allel on the secondary circuit for security in working. The Ganz motors (more fully described in THE ELECTRICAL WORLD of March 29, 1890) have two pairs of brushes, one of which leads in the current, and the other pair serves to short-circuit the magnet coils momentarily before the direction of current is changed, and a by-pass for the extra current is provided through a resistance attached to the brushes. The field intensity thereupon becomes high, and at a certain position of the brushes the incoming current and the extra current have the same direction, and this arrangement is the cause of the building up of the force in the motor. When synchronism is established the second pair of brushes is raised. The motors and gearing are of high workmanship, and work well. They have been in use since February, and by their operation have fully demonstrated their utility.

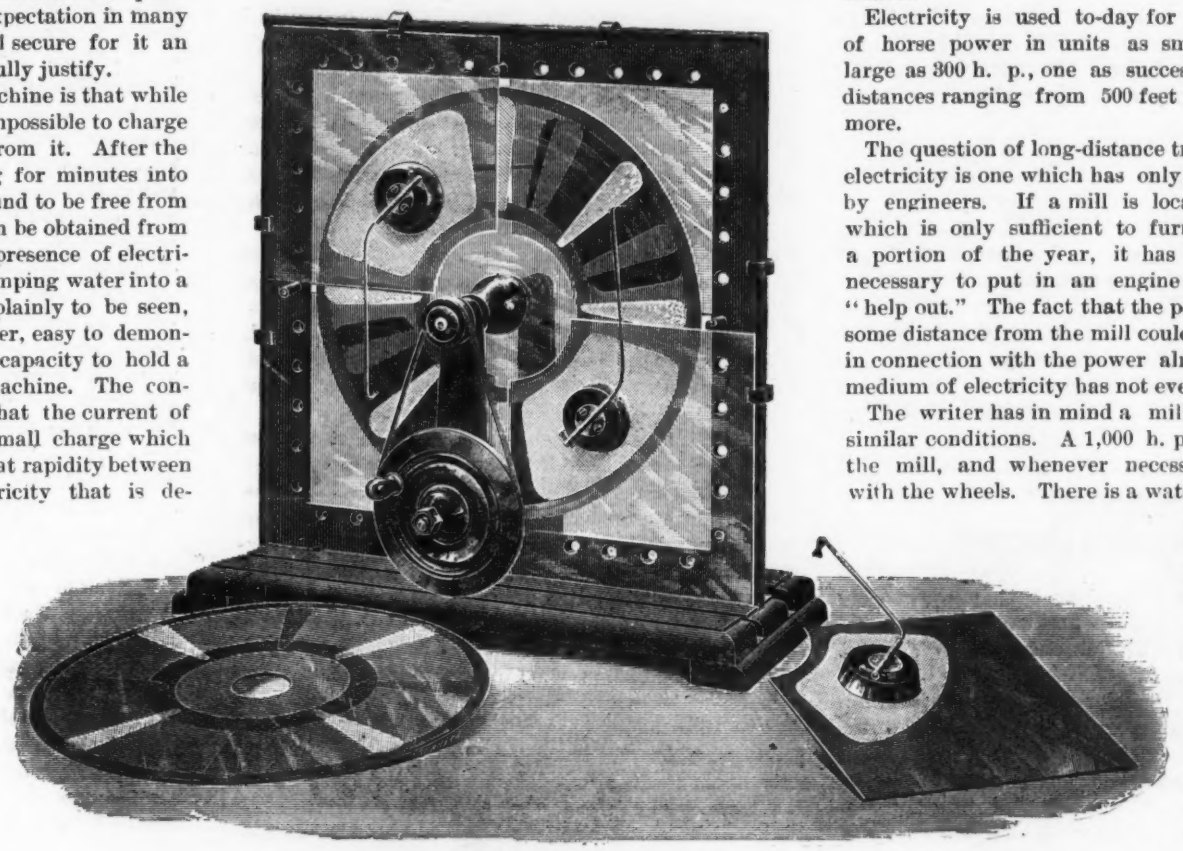
Wimhurst's Alternating Influence Machine.*

Among the various machines which have been constructed for the generation of statical or so-called frictional electricity, none can be compared with that of Mr. James Wimhurst, of the consultative staff of the Board of Trade, London, either for simplicity, reliability or efficiency. These merits of the Wimhurst influence machine are known to a very wide circle of electricians and physicists; consequently the news that the inventor has brought out another, having very curious and unlooked-for qualities, will be received with interest and expectation in many laboratories, schools and homes, and will secure for it an attentive reception, which its features fully justify.

A remarkable feature of the new machine is that while it gives an abundance of sparks, it is impossible to charge a Leyden jar or similar contrivance from it. After the electricity has been apparently flowing for minutes into the jar in rapid sparks, the latter is found to be free from all charge. Neither spark nor shock can be obtained from it, and delicate tests fail to reveal the presence of electricity in it. It is as if one had been pumping water into a bucket with no bottom; the stream is plainly to be seen, but nothing accumulates. It is, however, easy to demonstrate the integrity of the jar and its capacity to hold a charge when filled from an ordinary machine. The conclusion is, therefore, forced upon us that the current of sparks is really the oscillation of a small charge which flows backwards and forwards with great rapidity between the machine and the jar. The electricity that is developed is alternately positive and negative, and the normal condition of the jar is not upset.

If we investigate the action of the machine more minutely, by the aid of an electroscope of an exceedingly delicate construction, we find confirmation of the hypothesis that positive and negative electricity is produced alternately. Commencing to turn the disc exceedingly slowly, say at the rate of three or four revolutions per minute, the leaves of the electroscope suddenly diverge, being repelled from each other. They remain apart quite steadily until the disc has made rather more than three-quarters of a revolution, when they suddenly approach and cling together, showing that the sign of their charge has changed. They remain thus for an instant, and during another three-quarters of a revolution they again separate and go on. But if the disc be turned rapidly the leaves are no longer able to respond in this way to the changes of charge. Such light appliances, with their large surfaces exposed to the air, are incapable of rapidly approaching and receding through a considerable distance under the small stresses brought to bear upon them. They consequently take up a mean position between the extreme ends of the range, and show the alternate attractions and repulsions to which they are subject by a quick fluttering or tremor. It is abundantly evident that they are subject to varying stresses, which the retarding effect of the atmosphere will not allow them to completely obey.

The appearance of the machine is clearly shown in the accompanying illustration. A central spindle carries a glass disc 16 inches in diameter. This is varnished, and has affixed to it a number of sectors of tin-foil. The sectors measure four inches radially, while in breadth they may vary from one-quarter to five and a half inches. Usually the sectors on one side of the disc are arranged to break joint with those on the other side; but this is not essential. Indeed, in many respects the construction of the machine is very elastic, and many modifications are introduced. For instance, the number of tin-foil sectors may vary from 2 to 16 or more, on each side, and, as we have said, their relative positions on the two surfaces of the discs are not important. The results of different calculations are given in the accompanying table. The disc itself is mounted in the centre of and in the same plane as a wooden frame 20 inches square. This frame carries four inductors of the shape shown in the detached view; they are 9¼ inches square, with one corner cut away to admit the spindle and boss of the disc. Two of the inductors are mounted on each side of the frame, at opposite diagonal corners; those at the side of the machine the nearest the spectator are, say, at the upper left hand and the lower right hand corners. At the opposite side the inductors are at the upper left hand and the lower right hand corners. Upon each inductor plate is a tin-foil patch of the shape shown, measuring four inches radially and seven inches circumferentially. Other inductors are provided, having upon them the smallest tin-foil patch practicable. Cemented over each patch is a wooden disc, which on its face carries a bearing in which there rides a bent brass rod, having a plume of fine wires at its end, touching the glass discs at a point 90 degrees remote from the inductor, and opposite one of the inductors at the other end side of the plate. The disc is thus touched on both sides in two places. It is driven by a cord from a small hand wheel below and revolves in the direction of the hands of a clock. To further vary the capabilities of the machine a bar of insulating material is made to carry two metal wire plumes at its ends, these having metallic connection with two terminals; this device takes the place of two of the inductors and by its use a constant flow of electricity may be maintained.



WIMHURST'S ALTERNATING INFLUENCE MACHINE.

Discs.	Four Large Inductors.	Four Small Inductors.	Two Inductors and Rod.
Plain glass and no metal.	Is self-exciting with about 4 revolutions. Alternations occur each ¾ revolution.	Is self-exciting, but requires care. Alternations occur each ¾ revolution.	Is not self exciting, but requires little assistance. Constant current while not overtaxed; gives large current.
Two metal sectors each side.	Is self exciting. Alternations occur after each two sectors pass brush.	Is self-exciting. Alternations occur each ¾ revolution.	Is self-exciting. Constant current.
Eight metal sectors each side.	Is more freely self-exciting. Alternations occur each ¾ revolution.	Is self-exciting. Alternations occur each ¾ revolution.	Is self-exciting. Constant, but gives less current.
Sixteen metal sectors each side.	Is freely self-exciting with 3 revolutions. Alternations occur each ¾ revolution.	Is more freely self-exciting. Alternations occur each ¾ revolution.	Is freely self-exciting. Constant, but gives less current.
Sixteen sectors on one side.	Is self-exciting. Alternations occur each ¾ revolution.	Is self-exciting. Alternations occur each ¾ revolution.	Is self-exciting when sectors are next the rod. Is not self-exciting when sectors are next inductors. Constant in either case.

NOTE.—The principal features are: 1. That glass discs with no metal upon them are capable of self-excitement. 2. That the self-excitement increases about proportionally to the increase in the number of sectors. 3. That the quantity of electricity decreases about proportionally to size of sectors and also their number.

The machine which we illustrate has been constructed with the view of being most readily used for the purpose of demonstration and experiment. It is provided with several discs, having different arrangements of sectors, and all the parts are made interchangeable. By withdrawing the rear bearing the nut on the spindle can be screwed off at once, when half the boss comes away, and the disc can be withdrawn and be replaced by another in a few moments. The inductors lie on pegs on the square frame, and are held by light steel clips; provision is made by a number of holes in the frame for the use of inductors of different sizes. To couple one inductor to another, if such an arrangement should be desired, holes are bored in the wooden discs carrying the brush-holders, and into these holders the ends of wires can be inserted, the wires being bent in such a way as to join any pair of inductors. The parts of the machine are beautifully finished, and all the ends are attained by the simplest devices. The method of action of this instrument is not very easy to follow, and indeed no theory has yet been put forward in explanation of the results which flow from it.

*From *Engineering*.

Electricity in Mill Work.*

BY C. S. HUSSEY.

During the past few years the applications of electricity to power transmission have increased to such an extent that one can hardly realize it is a little more than ten years ago that electricity became of practical use to the commercial world. This increase is due to the great economy obtained in electrical transmission, and to the flexibility of the apparatus employed when installed under suitable conditions.

Electricity is used to-day for transmitting thousands of horse power in units as small as ⅛ h. p. and as large as 300 h. p., one as successfully as the other, over distances ranging from 500 feet or less to five miles and more.

The question of long-distance transmission of power by electricity is one which has only been recently considered by engineers. If a mill is located upon a water power which is only sufficient to furnish enough power for a portion of the year, it has always been considered necessary to put in an engine of sufficient capacity to "help out." The fact that the power of a fall, located at some distance from the mill could be utilized at the mill in connection with the power already there through the medium of electricity has not even been thought of.

The writer has in mind a mill which is located under similar conditions. A 1,000 h. p. engine is installed at the mill, and whenever necessary is run in connection with the wheels. There is a water power about two miles from the mill of over 2,000 h. p. capacity. How easy it would be to transmit this power to the mill, by proper electrical apparatus, and use it instead of the engine.

One of the large electric companies is at present building a generator and motor for use near Hartford, Conn., and the amount of power to be transmitted is 300 h. p. The source of power is located 10 miles away from where the power is to be utilized, 3,000 volts being used in this case, owing to the great distance carried.

Again, a large paper company located near Portland, Me., is driving its entire mill by electric power, which is transmitted a considerable distance. The voltage used in this instance is only 500, as the power is subdivided into small units and distributed throughout the mill.

This subject may be treated under the following heads: (1) Electricity as applied to isolated motors, located in different parts of a mill, and used to drive lines of shafting, separate machines, etc.; (2) electricity as applied to driving tram-cars suitable to handling all classes of goods, both in the mill and about the mill yard; (3) electricity as applied to hoisting machinery of all descriptions, including elevators, whip and drum hoists, etc.; and (4) electricity as applied to pumping machinery.

For transmitting power over distances, such as would occur about a mill, both generators and motors should be wound for 500 volts, as this would insure the greatest economy in copper wire without danger to persons handling the apparatus. It is always better where there are two or more machines in a generating station to drive each of them from the existing water or steam powers through the medium of a friction clutch; by this means any one of them can be stopped, if necessary, without any other part of the machinery being shut down. The amount of power which would be saved by doing away with cumbersome jack-shafts, heavy pulleys and dangerous belting has never been considered by many. As a rough approximation, 100 feet of shafting, three inches in diameter, and making 120 revolutions per minute, requires one horse power to overcome its friction, under conditions of fairly good alignment and good care. Should this shafting become out of alignment, as is frequently the case, its frictional resistance would be proportionally increased.

It has been estimated that from 30 to 50 per cent. of the power generated in mills and factories is unremunerative,

*Extract from a paper read April 29, before the New England Cotton Manufacturers' Association.

because of the wasteful method of driving in vogue at the present time. Should a judicious arrangement of electrical transmission be employed, on the contrary, fully 85 per cent. of the power developed by the wheels would be expended in useful work. Not only can power be saved by electrical transmission, but also a large amount of space is made available for other purposes, as an electric motor is of such dimensions that it can be suspended entirely out of reach, if necessary, on shelves or by other means, and driven in this position.

Another point which should be considered by millmen, and which would seem to be a very essential one, is this: By a sub-division of shafting into small units, a much more complete control is had over it in case of accident, or of any breakdown which is liable to occur, and which means, as mills are driven to-day, the shutting down of an entire room, and sometimes of an entire factory, at an immense loss while repairs are being made. On the contrary, should motors in small units be used, simply that portion of the room in which the breakdown occurred would be stopped, the rest of the mill running as before.

The question of the spreading of fire in mills is one of great interest to mill owners, and anything that could be devised to aid in preventing this should be carefully considered. One method which naturally suggests itself is to isolate each room in a factory as far as practicable, by closing all belt holes in floors and walls, thereby getting rid of that very dangerous element, the risk of carrying fire from floor to floor and room to room. No better method can be secured to accomplish this than the use of electricity for transmission. In cases where belt towers are used, the arrangement is generally a very costly one. The danger of fire occurring from the use of electricity has been reduced to a minimum by the many safeguards and protectors which are to be found in all well-installed plants.

By a properly proportioned winding of the armature and fields, automatic regulation of speed of less than 2 per cent. variation is obtained on all first-class motors, no matter what the variations of load may be. This feature is of special value, as it permits the simplest possible construction of the motor and at the same time secures an automatic regulation of speed well within the range of that which is guaranteed for the best regulated high-speed Sheave engines.

The electric mill tram way, in its sphere, has operated fully as successfully as the electric street railway, although its adoption has not been so general.

As yet many of the mills are not entirely willing to give up their old methods of transporting goods in and about their mill yards by means of hand or horse power and to install an electric tramroad, the first cost of which will amount to considerable, but after once put in secures a saving in operating expenses.

A mill tramway is practically a modified electric street railroad, the principle of propulsion being the same. Usually a single overhead trolley system is used, as in street railway work, the electricity being carried from the dynamo to the motors under the cars by means of this trolley, the rails of the track upon which the cars run being used to carry the current back to the generator. Where the motor car is to be run inside of buildings, however, two trolley wires are used, one for the same purpose as before, *i. e.*, to carry the current to the motor, while the second is used for carrying it back, instead of the rails. This is done in order to have a thoroughly insulated system throughout, and to do away with any sparking which might occur between the rails of the track and the revolving car wheels.

The amount of power generally used by motor cars in ordinary tramway work is either of three h. p. or six h. p.; the former easily handling a load of 5,000 pounds, and the latter a load of 10,000, exclusive of the weight of the car, at a speed of four miles per hour on level and straight track. These motors are mounted upon platform trucks of any convenient dimensions. As they are hung from the axles of the trucks, the platform itself is available for carrying the load. These cars can be used for towing other small cars if desired, thus increasing the carrying capacity of the system very materially.

The small motor cars are built to operate on any gauge, from 30 inches to the standard, four feet eight and one-half inches. Ordinary curves and grades offer no serious objection to the operation of the system, as electric cars are now doing successful work on tracks having curves of less than 15 feet radius and grades of over 12 per cent.

As before stated, the same generator used for furnishing power to stationary motors throughout the mill is equally available for supplying the necessary current for propelling the tramcars. However, should there be no other work performed about the mill electrically, a generator of sufficient size to operate the tramroad can be placed in the engine-room or wheelhouse, and run directly from the existing power; the engineer or wheelman being perfectly able to give it what little attention it may require, without in any way interfering with its regular duties.

For hoisting work machines are now made of almost any size and power, from 3 h. p., suitable for handling light loads at a high rate of speed, to 80 and 100 h. p. for heavy work.

On Constitution Wharf, in Boston, a large 45 h. p. motor is used to drive an elevator and also a long line of shafting running the entire length of the building, from which four friction whip hoists are operated. These whip hoists are used in handling light loads rapidly. They are comparatively inexpensive and do away with dummy engines or of a horse at one end of a rope slowly pulling up a barrel or bale at the other end, consuming a great deal of time, patience and money. These small friction whips after the design used at Constitution Wharf should receive the approval of millmen for use in cotton, wool or cloth storehouses. To-day in a great many places a dozen or more men are required to do the same amount of work that two men with a whip hoist could perform more quickly and easily.

An arrangement has been designed by the Thomson-Houston Motor Company in which a traveling overhead trolley carriage is used in connection with the friction hoist. With this arrangement a load can be picked up at one part of the storehouse and deposited in another part at any height desired.

While the question of adapting electricity to pumping may not have so much interest to millmen in general as the previous points brought up, still it may be of sufficient interest to warrant bringing to your attention a form of pump which is being used to a great extent by the Thomson-Houston Motor Company in connection with its motors.

This pump is manufactured by the Goulds Manufacturing Company, of Seneca Falls, N. Y., and is of the triplex, single-acting type. Three single-acting plungers, with their cranks hung from the main shaft at 120 degrees, are worked in three vertical cylinders. This arrangement is the best possible one for electric work, as it insures an almost constant load upon the motor at all points of the stroke. The Gould Manufacturing Company makes pumps of this design in all sizes from 2 × 4 inch cylinders for light work to 12 × 12 inch in course of design. The efficiency of these electric pumps has been shown by actual test to be fully equal to that of a steam pump of corresponding capacity and working under similiar conditions.

The smaller sizes of this pump are particularly adapted for fire purposes, as they can be distributed in different parts of the mill, power being carried to them by wires from the generator. They are always ready to be operated, and, because of their small size, can be placed in such a position as to be entirely out of the way of the every-day operations of the mill.

Electric pumps are intended to supersede steam pumps of any size, particularly if the location of the pump is any great distance from the source of power. With the efficiency the same, the electric pump can be operated much more economically owing to the small loss in power experienced in transmitting electricity as compared to the loss in transmitting steam an equal distance.

The advantage of the electrical system of power distribution in regular work has been shown to be as follows: It permits the utilization of water powers situated at distant or inaccessible points. In the absence of water power, electric transmission renders a concentration of steam plants possible. Small, expensive and perhaps troublesome steam plants are done away with, and in their place is a large, well-equipped and economical central station, from which the required amount of power, with small loss, is conveyed to the different motors wherever placed.

Annual and General Meeting of the American Institute of Electrical Engineers.

The spring meetings of the Institute will be held on May 19, 20 and 21, at its headquarters, No. 12 West Thirty-first Street, New York City. The preliminary programme as arranged by the Committee on Papers and Meetings and the Local Committee of Arrangements, is as follows:

The regular monthly meeting of council will be held in the secretary's office at 5 P. M., May 19. The annual meeting for the presentation of reports, election of officers and other business will follow at 8 P. M. on the same date.

The morning session, May 20, will assemble at 10 o'clock, when the following papers will be read: "The Development of the Dynamo," by Prof. Harris J. Ryan; "Evolution of the Stationary Electric Motor," by Dr. S. S. Wheeler; "Some Data Concerning the Photometry of the Arc Lamp," by Prof. E. L. Nichols. At the afternoon session of the same day the following papers will be presented: "A New Graphical Method of Calculating Leads for Wiring," by Carl Hering; "Street Car Motor Design," by H. F. Parshall; "Some Recent Improvements in Printing Telegraphs," by Henry Van Hoevenbergh; "A Proposed Electrical Equipment for the Coming Rapid Transit System of New York City," by Frank J. Sprague. The evening session will be held at Columbia College. This will consist of "Experiments with Alternating Currents of High Frequency," by Nikola Tesla.

Thursday morning, May 21, the members will meet at the Crocker-Wheeler Motor Company's factory, 430 West Fourteenth street. After an inspection of this establishment the meeting will re-assemble at 12 West Thirty-first street, when the following papers will be read: "A New Device for the Measurement of Alternating Current Potential," by Prof. Geo. S. Moler; "A Study of the Fluctuations of E. M. F. in the Open-Coil Armature of a Constant-Current Machine," by M. E. Thompson; "Some Results in the practical Utilization of Electric Welding," by Dr. F. A. C. Perrine. The papers to be read at the afternoon session, May 21, are: "Electric Meters," G. W. Walker; an address by Dr. W. H. Wahl on "The Aluminium Problem, Retrospective and Prospective"; also a paper entitled "Shall Aluminium be 'Alium,'" by Oberlin Smith. In connection with this subject there will be an exhibit of aluminium products. Thursday evening a reception will be tendered to the Institute by the New York Electric Club.

Visits to the different electrical establishments and objects of interest will also be arranged for Friday, May 22, an announcement of which will be published in the official programme.

The Magnetic Circuit of Transformers: Closed versus Open.*

BY S. EVERSHED.

(56) By this time the skeptical reader is probably looking for some justification of the views of transformer phenomena advanced in these papers. He wants to know what reasons can be given for preferring these vaunted practical notions to the old and complex analytical explanations of the phantom. Granted that the phantom has no relation to the real, have the transformers discussed here any resemblance to reality? Do these indicator diagrams represent facts? These are pertinent questions, and it is necessary to devote some space to their satisfaction. It should first of all be clearly understood that the analytical method must always fail to represent facts when iron forms the whole or any part of the magnetic medium in a transformer. Starting with the perfectly legitimate assumption of a sine E. M. F., analysis can only tell us what the value of the exciting current is when there is no hysteresis; for the attempt to find C necessitates the further assumption that $\mathbf{B}$ is expressible as a function of $\mathbf{H}$, and therefore C, in order that terms involving rate of change of induction may be simplified into terms involving rate of change of current, by which means the necessary relation between E and C can be expressed. But it is known that the fundamental law of magnetization of iron, nickel and cobalt (the magnetic metals) is now, and is likely to remain for a long time to come, a dark mystery; thanks to Dr. Hopkinson and Prof. Ewing we are beginning to see a faint glimmer, but hardly more than enough to enable us to perceive the almost hopeless clumsiness of our modes of thought when we are dealing with the ultimate construction of matter. For the present, then, it is mere waste of time—a darkening of counsel—to deal with an iron-cored transformer as though its coils had specifiable constant coefficients of self and mutual induction.

(57) The diagram method involves no assumption as to the relation of $\mathbf{B}$ to C. Starting, for example, with the assumption of a sine E. M. F. (an almost necessary assumption for analytical treatment, but not so for diagrams—only convenient), it is next assumed (but only for the moment) that the counter E due to changing induction in the core is also sinoidal; it follows that the induction itself must vary according to a sine law. The result of previous experiment on the magnetic properties of the iron core enables the proper value for the exciting current to be determined for each instant during the period. Now, it is clear that if the primary coil had no resistance the exciting current would require no electromotive force to maintain it, and the counter and impressed E. M. Fs. would be exactly equal and opposite at every instant. But the primary coil has a finite though small resistance, and this means that in addition to an impressed E. M. F. to balance the counter E. M. F. there must be just sufficient force to maintain the exciting current, an amount easily calculated by multiplying each instantaneous value of the current by the resistance of the primary coil. When all these values are added in their right order to the component E. M. Fs., balancing the counter E. M. Fs., the result is a wave of total E. M. F., which, if applied at the primary terminals, would produce the exciting current and induction waves given by the diagram. This E. M. F. wave is not really a pure sine function; as has already been noticed, the $C R$ part of the E is necessarily of the same shape as the current wave. Commercial transformers being made to carry the whole load current with a very small loss of volts over resistance, the value of $C R$ for the exciting current, which in a closed transformer is a very small fraction of the full load current, becomes vanishingly small when compared with the counter E. M. F. wave. Consequently indicator diagrams represent very closely indeed the actual behavior of real transformers.

(58) It must not be supposed for a moment that the construction of "no load" diagrams is impossible under some conditions; they may be useless, but they can be drawn for every condition. To take an extreme case, imagine No. 2 as a closed transformer had a primary coil of 2,240 turns as before, but instead of 1.4 per cent. drop at full load due to its resistance let it have a drop of 20 per cent. This requires the resistance to be about 107 ohms, and, since the maximum value of the exciting current is .162 ampère, the maximum value of $C R$ to maintain it is only 17.3 volts, so that even with an enormous full load drop the shape of the impressed E.M.F. wave would hardly differ appreciably from that of the counter E. M. F We do not assert that a given E. M. F. wave produces exactly specifiable current and induction waves, but given a counter E. M. F. wave (of any shape whatever), first the induction, then the exciting current, then $C R$, and finally the requisite E. M. F. wave may be found by drawing the

* Continued from The Electrical World, May 2, 1891.

diagram. It may be that the E. M. F. wave so found is one which no alternator produces, but it is absolutely certain that, given a suitable alternator, the transformer would run according to the diagram. When the E. M. F. wave is very nearly the same shape as the counter E. M. F. wave—a condition fulfilled with abundant accuracy by all commercial transformers—we may, if we please, begin by choosing a known wave form from some real alternator; then by drawing the counter E of the same form we can find the induction wave necessary to make such a counter wave. That is really the only difficult step in the progress from impressed E to exciting current. We have to find the integral of the counter E in order to plot **B**, and this is a tedious process unless E can be expressed by an

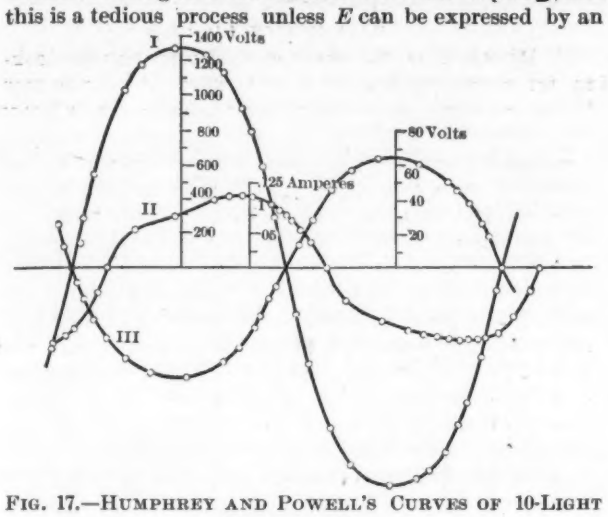


FIG. 17.—HUMPHREY AND POWELL'S CURVES OF 10-LIGHT TRANSFORMER.

integrable formula, for it is necessary to measure the area of the E curve from zero up to half a dozen or more equidistant epochs during a half period, and use the values of the areas as the ordinates of the induction wave. The writer hopes to deal with such non-analytical diagrams, as they may be called, in a future series of papers, where also the construction of diagrams for various loads on a transformer will be described. For the purpose of the present articles the "no load" diagrams give a sufficiently clear notion of the relation between exciting current induction and waste power.

(59) We have now, we hope, dispelled any suspicion that the diagrams involve a fallacy. Just where analytical treatment breaks down, the method of diagrams gives us what is wanted; it appeals to experiment for the relation between **B** and **H**; and the only error introduced is vanishingly small in the case of all real transformers. But although the diagrams may bring us to a perfectly logical conclusion on the assumed basis of fact, how if some phenomena of vital importance have been neglected? What if the supposed viscous hysteresis is a fact? What if it is possible to carry iron through cyclic changes in induction without loss of energy? Finally, suppose it is not necessary for the production of E. M. F. in the coils of a transformer that there should be any changing induction linked with them. These horrible suggestions are the result of certain recent experimental determinations of the losses in transformer cores made independently, and by different methods, by Mr. Mordey and Prof. Ayrton. It may as well be admitted at once that if their results are confirmed the diagram must be based on the new facts and those given in these papers will require revision. The

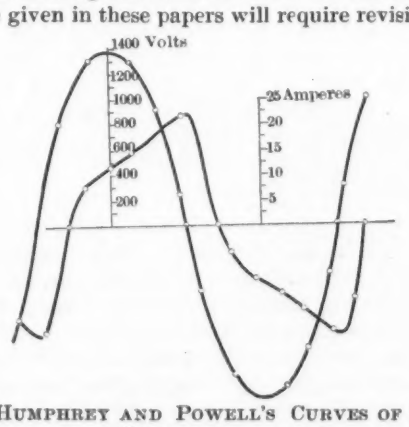


FIG. 18.—HUMPHREY AND POWELL'S CURVES OF 10-LIGHT TRANSFORMER.

case for and against open magnetic circuits would not be materially affected if these new phenomena became recognized as substantial facts. Viscous hysteresis could only lead to a greater waste in the core than that assumed in these papers, so that the arguments for the open circuit would be strengthened. The effect which seems to point to diminution of energy waste in the iron only occurs as the load on the transformer is increased, so that there can be but little advantage here for a transformer running practically unloaded for 16 or 20 hours a day; what little gain there might be is only of slightly more importance to the closed than the open transformer.

(60) Those who are inclined to accept the alleged phenomena alluded to in the last paragraph will do well to remember that other experimenters besides those mentioned have been working at the same problem, and have arrived at totally different results. While we in England are trying to force L, M, $\frac{dc}{dt}$ and cos θ on an unwilling transformer the American electricians are patiently and steadily adding to our knowledge of the real transformer by a direct appeal, not to Fourier's theorem, not to empirics, not to their imagination, but to Nature. The work done by Prof. Ryan and by various students at the Cornell University answers in the clearest manner some of the vexed questions respecting hysteresis and eddy currents. Prof. Ryan's method consists, shortly, in running a real live transformer under all sorts of conditions, and ascertaining the shapes and relations of the primary and secondary E and C waves by means of a revolving contact, which enables him to obtain the simultaneous values of E and C at any desired epochs during a whole period. He thus obtains an indicator diagram by observation, which stands in the same relation to the predicted diagrams given in these papers as an indicator card taken from an engine cylinder in actual work does to a diagram which might be predicted from the laws of heat. Several diagrams taken by Ryan's method from closed transformers are given by Messrs. Humphrey and Powell in a paper read before the American Institution of Electrical Engineers and published in the journal of that institution, vol. VII., No. 10. In Fig. 17 we reproduce the "no load" diagram for a 40 light transformer. It will be noticed that the exciting current, although following roughly the course we have predicted, differs in having its sharper corners rounded off to a large extent, so much so that the maximum value does not occur at the epoch when $E = 0$, as of course it should do if eddy currents are small. Turning back to Fig. 10 it will be readily understood that any large increase in the Y component will tend to displace the maximum value of $X + Y$, and lead to a curve more closely resembling that found by Humphrey and Powell. Another diagram is given in Fig. 18, taken from a 10-light transformer in which the induction density was far too high. Notice the increased sharpness of the turning points, and the sudden drop from maximum current to zero—precisely the results we should expect. The power wasted at no load in the 40-lighter is shown in Fig. 19, which is taken from the same paper. This curve includes C^2R loss in addition to the core waste.

(61) In the same volume of *Proceedings* a most interesting paper by Prof. Ryan is published in which the effect of temperature on core hysteresis is described, and in addition the observed energy loss from hysteresis when various cores were magnetized by an alternating current is compared with the loss calculated from Ewing's **B·H** curves for slow cycles. One of the most remarkable of these results is here reproduced in Fig. 20, where the

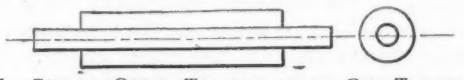


FIG. 21.—SMALL OPEN TRANSFORMER, ONE-TENTH FULL SIZE.

fine line is the **B·H** curve obtained by Ewing for "static" hysteresis, and the outer thick line is that deduced by Prof. Ryan by working back from the electromotive force and current waves to the induction wave and **B·H** cycle. The observed result includes any eddy currents there may have been in the core of iron plates on which the experiment was made, and is therefore naturally somewhat larger than the static curve, and slightly rounded at the turning points. As Prof. Ryan well says, "A study of these cards does not reveal that which can be recognized as a trace of viscous hysteresis." Speaking of his method generally, Prof. Ryan remarks with pardonable pride, "This method is found to be fully as accurate, and requires much less time and is more simplified than the analytic method making use of Fourier's theorem." Less time indeed, for our own professors spent years and covered acres of blackboards with the "analytic method," and after all had not discovered that the exciting current was other than a sine function! It takes about 45 minutes to obtain a diagram from a transformer, and every one can understand it when it is drawn. So far as they go, then, actual diagrams from live transformers agree broadly and substantially with our predicted diagrams. Unfortunately the authors of the papers we have referred to give no dimensions and details of the transformers, so that we are unable to work out the predicted diagram and so make an accurate comparison between theory and fact.

(62) The calculation of the exciting current for open magnetic circuits is of sufficient general interest to warrant a short comparison between the calculated values and actual results. Fig. 21 shows the core and primary coil of a small transformer designed by the writer. The details and dimensions are as follows:

TABLE XVI.—OPEN TRANSFORMER. OUTPUT 200 WATTS.
Maximum **B** = 8,600; F = 75.

Iron wire core, total length	= 40.4 cms.
" " area	= 4.5 "
Core projecting outside coil	= 7.0 "
Average diameter of primary coil	= 5.5 "

	Volts.	Turns.	Resistance.
Primary coil	2,000	15,000	470 ω

The usual formula gives 40,500 thoms* as the total induction required to produce 2,000 volts. Since the primary winding occupies so much space outside the core, the whole induction path may be divided in imagination into two parallel portions threading the primary winding, one via the iron core, the other in the space between the core and the average turns of the coil, to which may be added the small interstices between the wires forming the core. Calculate the magnetic resistance of these two paths separately. The circumference of the core is 8.5 centimetres, and as 7 centimetres project outside the coil at each end, there are 59.5 square centimetres of cylindrical surface, plus 5.7 centimetres on the end, or 65.2 square centimetres in all. A sphere of this surface has a radius of 2.28 centimetres, so that the resistance from pole to pole is $\frac{1}{2\pi \times 2.28} = .07$. The area inclosed by an average turn of the primary coil is 24.5 centimetres, of which 4.5 is occupied by iron, leaving an air path of 20 centimetres area and about 27 centimetres in length, the resistance of which is $\frac{27}{20} = 1.35$, and, if .07 is added for the external air path, we have a total of 1.42 for that part of the induction path which is composed entirely of air.

Since the core is traversed by something like 40,000 thoms, the density is nearly 9,000 gausses, and we may put **H** at about 10, or **H** $l = 400$, and the ratio of force to induction will be .01 for the core. This added to .07 for the external air path gives .08 as the magnetic resistance via

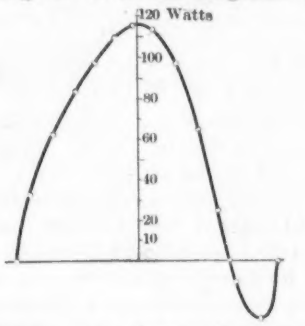


FIG. 19.—HUMPHREY AND POWELL'S CURVE OF WATTS WASTED ON OPEN CIRCUIT BY 40-LIGHT TRANSFORMER.

the core. If .08 and 1.42 are combined we arrive at the net magnetic resistance of the whole induction path; thus $\frac{.08 \times 1.42}{.08 + 1.42} = .076$. Since the whole induction is 40,500, we can estimate the exciting current as follows:

$$.4\pi\, N C' = 40{,}500 \times .076 \times 3{,}070,$$

and $C = \frac{C'}{\sqrt{2}} = \frac{3{,}070}{1.26 \times 15{,}000 \times \sqrt{2}} = .115$ ampère.

(63) When tested it was found that it required between .09 and .1 ampère to excite the transformer to 2,000 volts at a frequency of 75; the volts were measured by an electrometer which had been carefully calibrated and probably read within one, certainly within two, per cent. The current was measured by means of a Cardew voltmeter used as an ammeter, and the reading being very small was somewhat vague, but the current was certainly within the limits named. The method of "equivalent spheres" might be expected to overestimate the required current, for every assumption made tends to increase the calculated magnetic resistance. The induction is assumed to spread radially from each pole to infinity; it really takes a shorter path, curving round from pole to pole. The convention by which the whole induction is supposed to emerge from the core through so much of the ends as project from the core also leads to an overestimate; obviously a considerable fraction will leave the core a short distance within the coil at each end, and since it threads the greater portion of the whole coil it counts as useful induction. Practically, the calculation by "equivalent spheres" enables us to predict the exciting current required in a coil

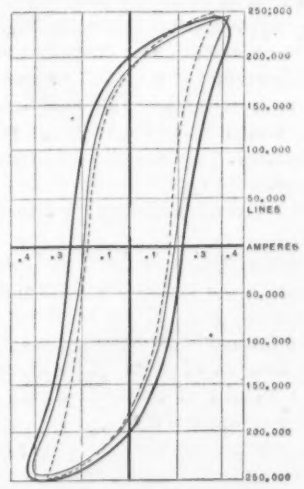


FIG. 20.—RESULT OF RYAN'S EXPERIMENTS. FINE LINE SHOWS EWING'S STATIC HYSTERESIS. FULL LINE SHOWS RESULT AT 138 PERIODS WITH 10-LIGHT TRANSFORMER.

to produce any given induction in its core with sufficient accuracy for most purposes, and with the certainty tha the actual will be rather smaller than the predicted current. A rough method of this sort is frequently of great service in designing electrical apparatus.

(64) If the exciting current for a "hedgehog" transformer is calculated on precisely the same assumption as to the surface of the equivalent spheres, and so on, the resulting value is still somewhat higher than the observed value. Taking Messrs. Swinburnes' 10 h. p. "hedgehog" as an example, we will calculate the exciting current. The dimensions of the transformer are almost identical in every respect save that of core area, with those of No. 3, as an open transformer (Fig. 7):

TABLE 17.—MESSRS. SWINEBURNE'S 10 H. P. "HEDGEHOG" TRANSFORMER.
Maximum **B** = 6,800; F = 100.

Length of core	73 cms.	
Area of core	40 "	
Volume	3,000 cub. cms.	approximately.
Radius of spherical ends	13 cms.	

The core is composed of iron wires, diam. = .056 cm.

	Volts.	Turns.	Resistance.
Primary	2,000	1,670	3.87
Secondary	100	84	.0072

*One thom = one magnetic line of force.

It will be noticed that, although the primary winding has fewer turns than No. 3 (Fig. 7), the maximum induction is under 7,000, as against 10,000; this is due, of course, to the higher frequency and greater core area. The only other striking difference between the genuine "hedgehog" and our imitation is in the resistance of the coils, which are only about one-half the amounts given for Fig. 7. This merely shows that Mr. Swinburne makes a smaller allowance for insulating space than that adopted by Mr. Ravenshaw, for in designing the coils for No. 3 we made the ratio of the spaces occupied by copper and insulation the same as we found them in the Ravenshaw transformer.

(To be continued.)

Notes on the Design of Multipolar Dynamos.*

BY W. B. ESSON.

5.—RELATION OF AIR GAP TO DIAMETER OF ARMATURE AND NUMBER OF POLES IN DIRECT-CURRENT MACHINES.

Having established the proportionality of the volume and diameter, it is easy to find the relation which must exist between the diameter and length of air gap for any particular angle of embrace, in order that sparking may not occur. I need not take up time ringing changes on the several equations, as to obtain the relation now referred to all that has to be done is to substitute for v in (1) its value in terms of the diameter accordingly as the winding is of the cylinder or drum type, and find the connection between l and d. Preserving the same safety factor throughout, it will be found that two-pole dynamos with a mean gap induction of 5,000 C. G. S. units per square centimetre, and pole pieces embracing an angle of 130 degrees, must have—the volume being related to the diameter as described—gap of not less than .036 d if cylinder wound, or .054 d if drum wound. As will have been observed, the air gap may diminish as the induction is increased or as the volume is reduced.

But, as is also seen from the equation, the gap required for any particular volume is proportional to the angle of embrace, and if we substitute for two poles a greater number of correspondingly less angular width, working with an increased diameter and volume without a proportionally increased gap is made possible. This is where the advantage of the four, six, or even eight pole machine comes in. Keeping to two poles, increasing the diameter requires either a proportional increase in the gap, whether the space is required for the conductors and clearance or not, or an increased induction, or a diminished polar angle, or a combination of these. In either case, the magnetizing force spent in the gap is increased; and, other things remaining the same, obviously it would be of some advantage to adopt a construction which, while producing no greater tendency to sparking, would admit of the air gap being reduced until its length was just sufficient to accommodate the conductors and allow of the necessary clearance. The work done by an armature of given external dimensions we have seen to be quite independent of the number of poles, and the choice of this number can only be a question, therefore, of structural and working economy.

6.—DIMENSIONS OF THE ARMATURE.

It has been observed that the output of an armature is proportional to $d^2 L$; and, the induction being the same, the weight of the core for a given number of poles must be proportional to the output, the radial depth increasing directly as the diameter, so that a proportionally increased field may be carried. The number of poles being fixed, the weight of the core for a given output may be taken, therefore, as approximately constant, whatever the ratio of L to d.

As the number of poles is increased, the induction remaining the same, the radial depth of the core is diminished in proportion, and, within the limits of practice, we may make the further assumption that the weight is inversely as the number of poles. The money value of a reduction in the weight of material due to increasing the poles can easily be arrived at.

The power wasted in hysteresis is proportional to the weight of iron magnetized, and to the number of reversals per second. The weight being inversely, and the reversals directly, as the number of poles, the power wasted is for a given output the same; furthermore, as the output is proportional to the speed, we may say that for a given induction the loss in hysteresis is about proportional to the output only, without reference to speed of rotation, weight of core, or number of poles. If it be more important to reduce the loss by hysteresis than to reduce the weight of material, it can, of course, be done. It is a point for the designer to consider.

So much for the core; let us now consider the copper part. Taking Gramme-wound armatures having an interior opening equal to .66, or two-thirds of the core diameter, is is found—the output, speed and temperature being predetermined—that the ratio of L to d may vary through a considerable range without making any great difference in the weight of copper or efficiency. For instance, the most efficient relation being $L = \frac{d}{3}$, it may be varied on the one hand till $L = d$, or on the other till $L = \frac{d}{6}$, without increasing the copper by more than about 10 per cent. Of course the watts wasted in the armature are correspondingly increased, but within the limits of the large variation mentioned the reduction in the electrical efficiency of the machine is under one-half per cent. In two-pole machines L varies from .5 to 1.5 d, the normal relation being about $L = d$. As has been seen, the gap has to be increased in proportion to the diameter, unless a greater number of poles be employed; and the disadvantage of an increased magnetizing force would, in machines with only two poles, counterbalance the slight advantage of getting the armature dimensions nearer the best proportion. When the poles are increased, however, the gap may remain fixed, and if the radial depth of the core be correspondingly diminished, the proportions for least copper and highest efficiency are altered: thus in a four-pole Gramme we can work from $L = \frac{d}{3}$ up to $L = \frac{d}{12}$ without a greater variation than 10 per cent. in the weight of copper. Observe, this is a question differing

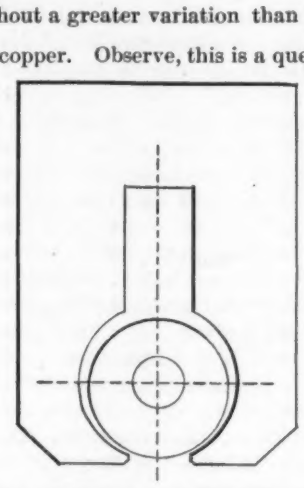


FIG. 3.—CROSS-SECTION OF A TWO-POLE MACHINE.

altogether from the one which was considered in my former paper. In that case the length and radial depth of the armature over the winding were fixed, the problem then being to find the best relation of copper to iron. Here both radial depth and length of core alter, also the peripheral velocity, though the revolutions per minute remain the same. Why the velocity is allowed to alter will be immediately apparent; I only show at the moment that the dimensions of the armature may have their relations altered considerably without making any considerable difference to the weight of copper or efficiency.

To the drum-wound armatures precisely the same reasoning applies. Here, speed and temperature being fixed as before, the best proportion for two-pole machines is about $L = 3.3\ d$; but because of the distance between the bearings which such a relation would necessitate being inconveniently great, we rarely find $L = 2\ d$ exceeded. The latter requires about 5 per cent. more copper than the former, while for the usual proportion, $L = 1.5\ d$, 12½ per cent. more is required than for $L = 3.3\ d$. The variation which can be made without overstepping the limits of economy has a smaller range in drum than in cylinder machines, owing to the greater relative importance of the end wires, because of their greater length. If the length of the core is reduced below $L = 1.5\ d$, the copper in machines with two poles increases rapidly; but if the number of poles be increased, the length of the end wires being shortened nearly in proportion, the core length may be reduced to a fraction of the diameter without sacrifice of copper or efficiency. In a four-pole machine, for instance,

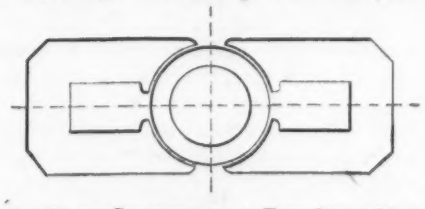


FIG. 4.—CROSS-SECTION OF A TWO-POLE MACHINE.

the same copper is used with $L = .5\ d$ as in a two-pole one with $L = 2\ d$; while for six poles, without increasing the copper, the relation may be as small as $L = .25\ d$. The effect of adding poles when the diameter is relatively great is not so noticeable in Gramme-wound machines, as the end wires are less important.

All the above facts go to prove that if there is anything to be gained, as regards the production of the field, by increasing the diameter of the armature and the number of poles, there is nothing, considering the armature by itself, to be lost by it. It may, in fact, be rather an advantage, because the weight of the iron core is reduced. It is true the peripheral velocity is increased; but this does not matter in the least, provided a certain limit is not exceeded. Opinions differ as to what the limit should be, some machines working at 50 feet per second, others at 100, and a few as high as 125. But there is no reason whatever why any properly constructed armature should not run at a periphery speed of 100 feet per second; and, provided this velocity is not exceeded, any advantage which may be obtained by a relatively large armature and increased number of poles should be secured.

7.—DIMENSIONS OF THE FIELD MAGNETS.

It will be apparent, from the foregoing considerations, that the employment of two or more than two poles for direct current machines of moderate dimensions resolves itself mainly into a deliberation regarding the most economical shape to give to the field magnets. As regards the armature, considered by itself, we may say that the choice of dimensions is mostly a matter of convenience, seeing that the amount of copper required and efficiency are for a given output practically unaltered by variations in this respect, while the reduction in the weight of the core due to an increased number of poles is to some extent compensated by the extra expense of larger plates and increased weight of the armature supports. Again, the cost of labor is increased by the larger diameter; but, everything being taken into account, considerations respecting the armature do not influence the design to a very great extent. One thing in favor of increasing the poles, as far as the armature is concerned, must, however, be remembered, and that is the reduction, consequent on a smaller conductor being used, of the losses arising from parasitic currents. We now turn our attention to the magnets.

I have said that for the prevention of sparking it is necessary that the induction per square centimetre remaining the same, the air gap increases proportionally to the diameter, whether the space is necessary for conductors and clearance or not, but that the coefficient by which the diameter has to be multiplied to give the length of the gap necessary to prevent sparking diminishes directly as the pole angle. In comparing the magnetic system of a four or six pole machine with that of a two-pole one, it is necessary to adopt dimensions for the armature in accordance with the considerations already mentioned; hence, if the two-pole armature had a length of core equal to one and a half times its diameter, in a four-pole one the length should be about half the diameter. The diagrams (Figs. 3 and 4) show the cross sections of two such machines. The diameter of the four-pole armature is 1.4, and its length .5 times that of the two-pole one, consequently both machines give the same output. The weight of the two horseshoe magnets in the four-pole machine comes to 56 per cent. of the weight of the single horseshoe magnet, which indicates in this particular case a considerable saving in wrought iron. In taking the copper weight it is necessary to bear in mind that this does not vary simply as the length of the wire if the machines are of the same efficiency, but as the square of the length; so in this particular comparison the copper on the two horseshoes would be, roughly, 30 per cent. more than on the single horseshoe, assuming the length of the air gaps to be the same. Now, if it were possible to reduce the gaps by 12 per cent. or so, the copper weight would be similar in both machines, and we should have credit for a certain amount of iron saved in the construction of the four-pole one, which could be balanced against the increased expenditure for labor. If the gap can be reduced by more than 12 per cent.—always retaining the depth of the winding the same—there is a saving of copper as well as iron, and it is simply the comparison between the value of the copper and other materials used, and the cost of the labor in the two cases which determines, at least in machines of moderate size, whether two or more poles should be adopted.

(To be continued.)

*Continued from THE ELECTRICAL WORLD, May 2, 1891.

Electric and Magnetic Screening.*

BY SIR WILLIAM THOMSON.

There are five kinds of screening against electric and magnetic influences, which are quite distinct in our primary knowledge of them, but which must all be seen in connected relation with one another when we know more of electricity than we know at present:—I. Electrostatic screening. II. Magnetostatic screening. III. Variational screening against electromotive force. IV. Variational screening against magnetomotive force. V. Fire-screens and window-blinds or shutters.

I.

Electrostatic screening is of fundamental significance throughout electric theory. It has also an important place in the history of natural philosophy, inasmuch as consideration of it led Faraday from Snow Harris' crudely approximate but most interestingly suggestive doctrine of non-influence of unopposed parts and action in parallel straight lines between the mutually visible parts of mutually attracting conductors, to his own splendid theory of inductive attraction transmitted along curved lines of force by specific action in and of the medium intervening between the conductors.

A continuous metallic surface completely separating inclosed air from the air surrounding it acts as a perfect screen against all electrostatic influence between electrified bodies in the portions of air so separated. This proposition, which had been established as a theorem of the mathematical theory of electricity by Green, in the ninth article of his now celebrated essay (see pp. 14 and 48 of the reprint edited by Ferrers), was admirably illustrated by Faraday, by the observations which he made inside the wooden cube covered all around with wire netting and bands of tinfoil, which he insulated within this lecture-room ("Experimental Researches," 1,173, 1,174). "I went into the cube and lived in it; and, using lighted candles, electrometers, and all other tests of electrical states, I could not find the least influence upon them, or indication of anything particular given by them, though all the time the outside of the cube was powerfully charged, and large

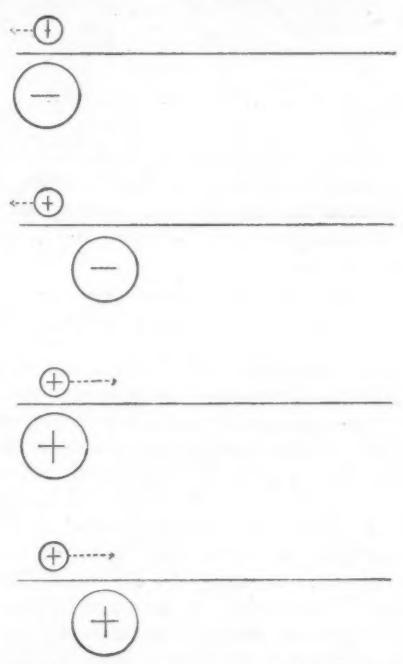
*Delivered at the Royal Institution, London.

sparks and brushes were darting off from every point of its outer surface."

The doctrine of electric images is slightly alluded to, and an illustrative experiment performed, showing the fixing of an electric image. The electroscope used for the experiments is an electrified pith ball, suspended by a varnished double silk fibre of about 9 or 10 feet long. Figs. 1–4 represent experimental illustrations, in which the pith ball, positively electrified, experiences a force due to electrified bodies, optically screened from it by a thin sheet of tin plate. In Figs. 1 and 2 the pith ball is attracted round a corner by a stick of rubbed sealing-wax, and in Figs. 3 and 4 repelled round a corner by a stick of rubbed glass. In Fig. 2 the sealing-wax *seems* to repel the pith ball, and in Fig. 4 rubbed glass *seems* to attract it. This experiment constituted a very palpable illustration of Faraday's induction in curved lines of force.

In the present lecture some experimental illustrations were given of electrostatic screening by incomplete plane sheets and curved surfaces of continuous metal, and of imperfectly conducting material, such as paper, slate, wood, and a sheet of vulcanite, moist or dry, window glass at ordinary temperatures in air of ordinary moisture, and by perforated metal screens and screens of network, or gratings of parallel bars.

The fixing of an electric image is shown in two experiments: (1) the image of a stick of sealing-wax in a thin plane sheet of vulcanite, moistened, warmed, and dried under the electric influence by the application and removal of a spirit-lamp flame; (2) the glass jar of a quadrant electrometer with a rubbed stick of sealing-wax held projecting into it, while the outer surface is moistened, warmed and dried by the application and removal of a



FIGS. 1 TO 4.—EXPERIMENTAL ILLUSTRATIONS OF ELECTRIC AND MAGNETIC SCREENING.

ring of flame produced by cotton wick wrapped on an iron ring and moistened in alcohol.

Fig. 5 is copied from a diagram of Clerk Maxwell's to illustrate screening by a plane grating of parallel bars of approximately circular cross section, with distance from centre to centre 12 times the diameter of each bar. ("Electricity and Magnetism," Vol. I., Art. 203, Fig. 13) It represents the lines of force due to equal quantities of opposite electricities on the grating itself, and a parallel plane of continuous metal (not shown in the diagram) at a distance from the grating of not less than one and a half times the distance from bar to bar. The shadings show the lines of force for the same circumstances, but with oval bars instead of the small circular bars of Maxwell's grating. It is interesting to see how every line of force ends in a bar of the grating, none straying to an infinite distance beyond it, which is necessarily the case when the quantities of electricity on the grating and on the continuous plane are equal and opposite. If an insulated electrified body, with electricity of the same name as that of the grating, for example, is brought up from below, it experiences no electric force differing sensibly from that which would be produced by its own inductive effect on the grating, till it is within a less distance from the grating than the distance from bar to bar, when it experiences repulsion or attraction, according as it is under a bar of the grating or under the middle of a space between two bars. If there be a parallel metal plane below the grating, kept at the same potential as the grating, it takes no sensible proportion of the electricity from the grating, and experiences no sensible force when its distance from the grating exceeds a limit depending on the ratio of the diameter of each bar to the distance from bar to bar. The mathematical theory of this action was partially given by Maxwell (Arts. 203–205), and yesterday I communicated an extension of it to the Royal Society.

II.

Magnetostatic screening by soft iron would follow the same law as electrostatic screening, if the magnetic susceptibility of the iron were infinitely great. It is not great enough to even approximately fulfill this condition in any practical case. The nearest approach to fulfillment is presented when we have a thick iron shell completely inclosing a hollow space, but the thickness must be a considerable proportion of the smallest diameter, not less than $\frac{1}{10}$, perhaps, for iron of ordinary magnetic susceptibility to produce so much of screening effect that the magnetic force in the interior should be anything less than 5 per cent. of the force at a distance outside, when the shell is placed in a uniform magnetic field. The accompanying diagram, Fig. 6, representing the conning tower of H. M. S. Orlando, and the position of the compass within it, has been kindly sent to me by Captain Creak, R. N., for this lecture, by permission of the Controller of the Navy. It gives an interesting illustration of magnetic screening effect

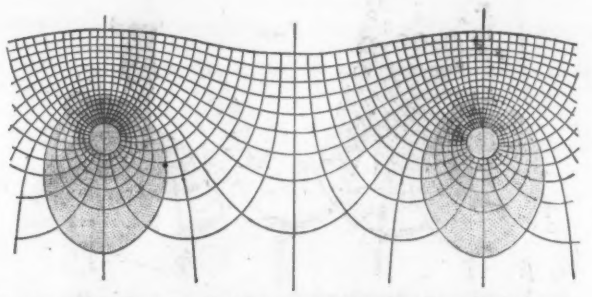


FIG. 5.—MAXWELL'S DIAGRAM TO ILLUSTRATE SCREENING.

by the case of a belt of iron, 1 foot thick, 5 feet high, and 10 feet in internal diameter, with roof and floor of comparatively thin iron. Captain Creak informs me that the average horizontal component of the magnetic directing force on the compass in the centre of this conning tower is only about one-fifth of that of the undisturbed terrestrial magnetism.

An evil practice, against which careful theoretical and practical warnings were published two or three years ago,* and which is now nearly, though, I believe, not at this moment quite thoroughly, stopped, of what is called single wiring in the electric lighting of ships, has been fallaciously defended by various bad reasons, among them an erroneous argument that the ship's iron produced a sufficient screening effect against disturbance of the ship's compasses, by the electric light currents, when that plan of wiring is adopted. The argument would be good for a ship 50 feet broad and 30 feet deep, if the deck and hull were of iron three feet thick. As it is, mathematical calculation shows that the screening effect is quite small in comparison with what the disturbance of the compass would be if the ship and her decks were all of wood. Actual observation, on ships electrically lighted on the single wire system by some of the best electrical engineers in the world, has shown, in many cases, disturbance of the compass of from 3 degrees to 7 degrees, produced by throwing off and on the groups of lights in various parts of the ship, which are thrown on and off habitually in the evenings and nights in ordinary and necessary practice of sea-going passenger ships. When the facts become known to shipowners, single wiring will never again be admitted at sea unless the alternating current system of electric lighting is again adopted. But, although this system was largely used when electric lighting was first introduced into ships, the economy and other advantages of the direct-current system are so great that no one would think of using the

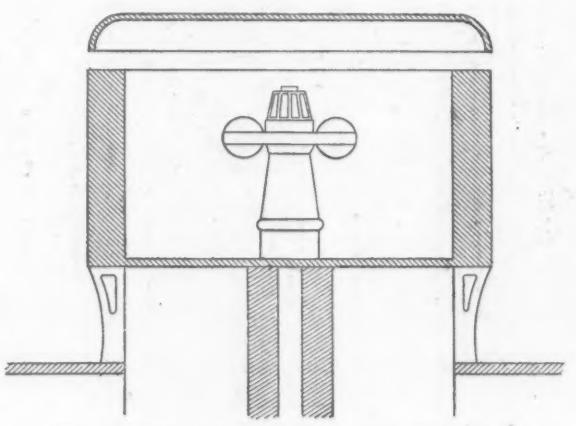


FIG. 6.—CONNING TOWER OF THE ORLANDO.

alternate system for the trivial economy, *if any economy there is*, in the single wire, as compared with the double insulated wire system.

An interesting illustration of a case in which iron, of any thickness, however great, produces *no screening effect* on an electric current, steady or alternating, is shown by the accompanying diagram, Fig. 7, which represents in section an electric current along the axis of a circular iron tube, completely surrounding it. Whether the tube be long or short, it exercises no screening effect whatever. A single circular iron ring, supported in the air, with its plane perpendicular to the length of a straight conductor conveying an electric current, produces absolutely no disturbance of the circular endless lines of magnetic force which surround the wire; neither does any piece of iron, wholly bounded by a surface of revolution, with a straight conductor conveying electricity along its axis.

* See a paper read before the Institution of Electrical Engineers (London), by Sir William Thomson, "On the Security against Disturbance of Ships' Compasses by Electric Lighting Appliances."

The Superposition of Longitudinal and Transverse Magnetizations.

It has been demonstrated experimentally by Jamin that two longitudinal magnetizations of inverse polarity may be superposed, as it were, upon the same plate of steel, and that they neutralize without destroying each other; while H. C. Decharme has shown that the same thing occurs in the case of two transverse magnetizations of contrary polarity (*vide Comptes Rendus*, Aug. 18, 1890). At a meeting of the Paris Academy of Science on March 9 Decharme described some further experiments upon the superposition of longitudinal and transverse magnetizations. These conditions were successively communicated to the same plate of steel, and it was found that in this case neutralization, properly so called, did not take place, the acting forces being no longer directly opposed, but perpendicular one to the other.

After having magnetized a plate of steel 100 millimetres long by 28 millimetres broad and 3 millimetres in thickness, and then magnetized it transversely by one of the methods indicated in the previous communication, Decharme found that the effects of both these magnetizations were shown simultaneously to a more or less perfect degree, or else that the longitudinal magnetization disappeared and gave place to the transverse magnetization which was produced last. By practicing a few more longitudinal passes the transverse magnetization can in this case be caused to disappear and to give place to the phenomenon of longitudinal magnetization.

Either condition may be replaced by the other by slightly modifying the conditions of the experiment. When, however, these alternate transverse and longitudinal conditions of magnetization are continued for some time the magnetic "layers" increase more and more, and the steel tends toward saturation. As this point is approached it begins to be sufficient to make fewer and fewer passes in order to cause one or the other of these

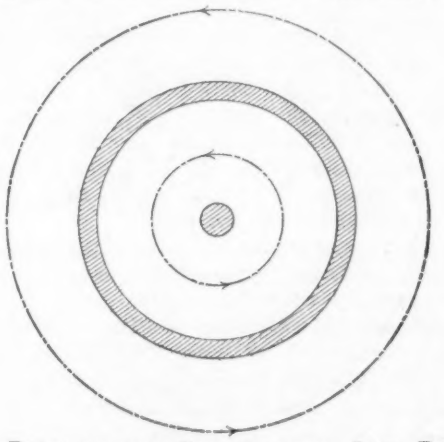


FIG. 7.—DIAGRAM OF A CASE IN WHICH IRON PRODUCE NO SCREENING EFFECT.

conditions to predominate. In fact, a sort of unstable equilibrium is reached in which the smallest addition of force will cause a disturbance. The extreme to which this may be pushed may be called the *critical point*.

Decharme considers that circular and helicoidal magnetization can be conceived possible, and might be obtained by suitably combining the action and direction of the magnetic forces.

Statistics of Street Railways.

Superintendent Porter, of the Census Bureau, publishes a bulletin about the relative economy of cable, electric and animal motive power for street railways. It was prepared by C. H. Cooley, under the supervision of Henry C. Adams, the statistician of the Interstate Commerce Commission. While it is stated that it is too early to form a final judgment regarding the value of electric motive power for this purpose, yet the statistics throw considerable light upon the matter. The bulletin covers statistics of 50 lines of street railway, 10 of which are operated by cable, 10 by electricity and 30 by animal power.

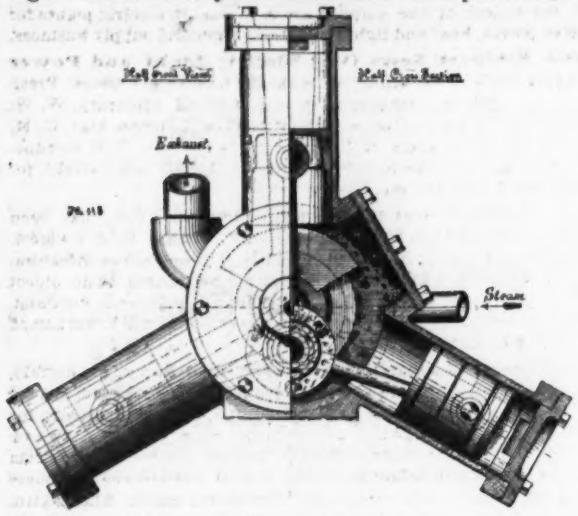
The total cost of the 10 cable roads, including equipment, was $26,351,416; total number of passengers carried. 101,995,695, at a total cost of $3,286,461. The operating expenses per car mile were 14.12 cents, and the operating expenses per passenger 3.22 cents. The length of all tracks was 143 miles. The total cost of the 10 electric roads, including equipment, $2,426,285; total track mileage, 67.22 miles; total number of passengers, 8,031,214, at a cost of $326,961, or 13.21 cents per car mile and 3.82 cents per passenger. The operation of electric railways is less settled and uniform than either cable or horse railways. The total cost of the 30 horse car lines, with equipment, was $22,788,277, with 552 miles of track; operating expenses for the year, $6,986,019, with 190,434,783 passengers; expense per car mile, 18.16 cents, and cost per passenger 3.67 cents. The expense per car mile on cable roads varies from 9.59 cents to 21.91 cents; on electric roads, from 8.34 cents to 36.04 cents; on animal roads, from 9.10 cents to 27.02 cents.

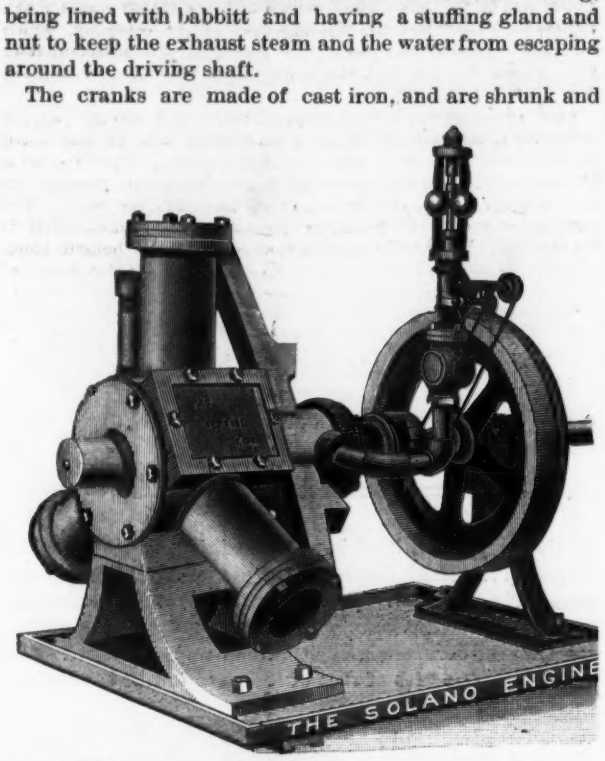
As far as the operating expense per car mile is an index of economy in operation, both cable and electric railways are cheaper than railways operated by animal power. The cable railways were built at a cost per mile of street occupied of over seven times as much as the electric railways were. The passenger traffic is about six times as great

upon the cable as upon the electric railways. The figures correspond to the generally accepted fact that cable railways attain their greatest efficiency where an extremely heavy traffic is to be handled.

The Solano High Speed Engine.

In the Solano high speed engine, shown in the accompanying illustrations and manufactured by Howard & Morse, of 45 Fulton street, New York City, the steam is delivered in a distributing chamber in the valve. This chamber has a steam port that registers with each cylinder port as it rotates, distributing the steam to the cylinders as the piston reaches the extreme outward position, thus giving a constant rotary motion to the crank pin from the





FIGS. 1 AND 2.—SOLANO HIGH SPEED ENGINE.

fact that the force is operating from three different points. The exhaust of the cylinders is accomplished by the same valve, the valve chamber being divided by a Z-shaped partition that permits the exhaust port in the valve being made so that it will rotate in the same line as the steam ports of the cylinders, thus exhausting the cylinders successively into the crank case, and from there into the atmosphere through the exhaust pipe.

In the same line around the valve as the steam and exhaust ports, and following the exhaust port, there is a small port that registers with the cylinders when the pistons have nearly reached their outer position. The purpose of this port is to relieve the cylinder of any water that might have accumulated from condensed steam when first starting. This port is kept closed by a pressure valve so adjusted that it will only open when a certain pressure has been attained.

The cylinders, body and valve chamber are all cast in one piece. The cylinder heads cover the outside end of the cylinders, the other end being uncovered and opening directly into the chamber of the crank case. The pistons are of the "trunk" form, being made very light and strong and carrying the steel wrist pins, and are packed with one snap ring and three water grooves.

The connecting rods are made of forged steel without a weld and completely finished, having keyed on the driving shaft and steel crank pin, and have a space in them for counter weights to balance the engine.

The side cover on the crank casing must be removed to examine the crankpin connections.

grooves forms a perfect water film that prevents the escape of steam.

The valve is rotated by an equalizing device placed between the valve and the collar, which is secured to the shaft, so that a uniform driving strain is applied to both sides of the valve, thus preventing uneven wear.

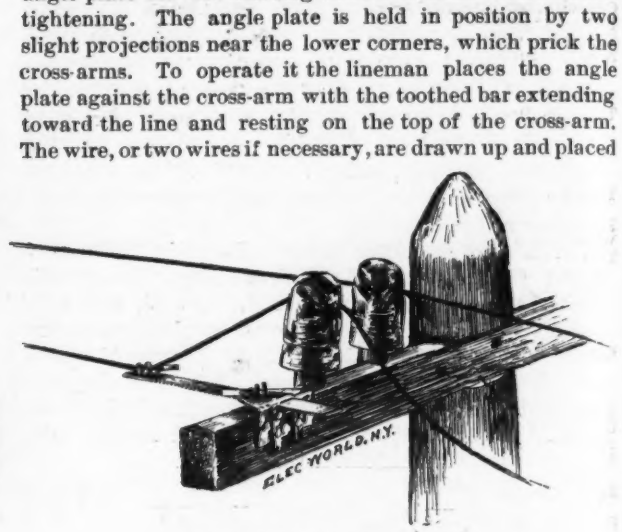
The valve chamber cover serves also as a back bearing, being lined with babbitt and having a stuffing gland and nut to keep the exhaust steam and the water from escaping around the driving shaft.

The cranks are made of cast iron, and are shrunk and

Cope's Wire Tightener.

The object of the appliance shown in the accompanying illustration is to tighten wires or cables between poles before securing them to the insulators, and for holding them while being secured. By this apparatus one man can draw a wire or cable sufficiently taut without assistance and secure it under these conditions. The device consists of a spring steel bar $\frac{3}{32}$ of an inch thick, with saw teeth on both sides passing through the bracket or clamp and engaging two spring catches or pawls shown on the vertical part of the angle clamp.

On the outward end of said bar are two self-acting clamps with corrugated bearings that grip the wires tightly and quickly. There are also two clamps on the top of the angle plate for the holding of the wire or wires before tightening. The angle plate is held in position by two slight projections near the lower corners, which prick the cross-arms. To operate it the lineman places the angle plate against the cross-arm with the toothed bar extending toward the line and resting on the top of the cross-arm. The wire, or two wires if necessary, are drawn up and placed



COPE'S WIRE TIGHTENER

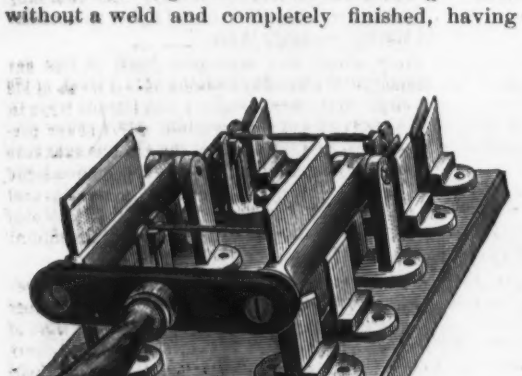
between the self-acting clamps at the end of the toothed bar. The end is then moved back and forth, causing the toothed bar to rack back through the angle clamp and retaining catches with great power, and drawing the cable or wires to any desired tension.

The Bagnall Fuse Switch.

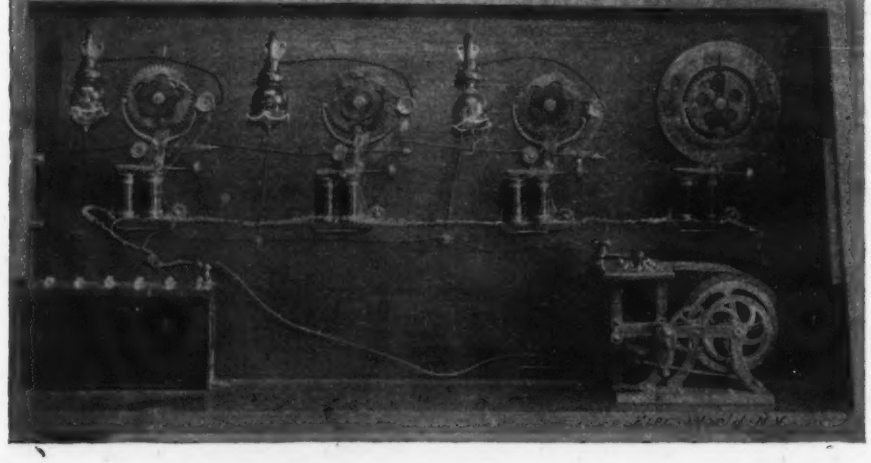
In the accompanying illustration is shown the substitute for circuit-breakers which the Emerson Electric Manufacturing Company, of St. Louis, Mo., has placed upon the market. A piece of ordinary fuse wire is used in connection with a knife switch. Its construction will be readily seen from the illustration.

The McCann Signaling System.

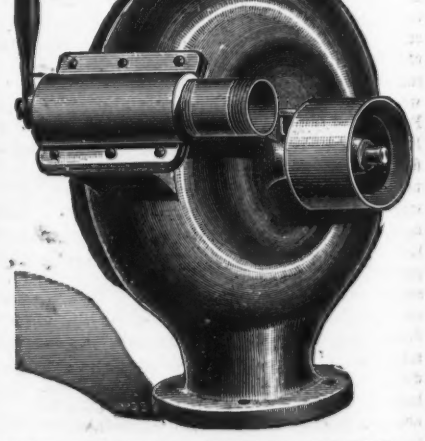
Mr. W. R. McCann, of Chicago, Ill., has invented an ingenious system of electric signaling by means of light flashes from certain lamps of a series or line. The system is to be used for signaling railroad trains between stations, transmitting messages by signal in mines, calling policemen to patrol boxes, or for any other purposes of a similar



THE BAGNALL FUSE SWITCH.



THE McCANN SIGNALING SYSTEM.



THE STILWELL WATER MOTOR.

the composition bushing driven in tight where it connects to the wrist pin.

The main crank shaft bearing is securely fastened to the main casting by screws and can easily be replaced at any time when it becomes worn. This bearing is lubricated by oil that works through with the steam, thus insuring a constant and perfect lubrication at that point.

The front bearing and cover hold an outside bearing which is lined with babbitt. This cover must be removed to gain access to the crank connection. The adjusting screws in the rings can be tightened to take up the lost motion between the crank pin and the connecting rods that work on the sleeve or bushing.

The valve is a rotary one, having steam, steam exhausts and pressure relief valve ports all combined in one piece; also a sufficient number of water grooves for packing. Should the engine be blocked and a full head of steam turned on, the valve would leak badly. It has been demonstrated by actual work that the moment the engine starts the centrifugal force of the water in the water

nature. In the case of train signaling a line will be set with signal poles, say, a mile apart, each with an incandescent lamp. From the station will be run a single wire from the device shown in the illustration, which is to control the flashes of the signal lamps. At each pole is placed an independent set of "Ajax" battery cells, to be connected to the lamp through an automatic switch, operated from the signal line by means of current impulses sent from the station.

As shown in the illustration, the station apparatus consists of a combined rotary drum and key, by moving which the operator can light any one lamp or any series of lamps, there being a main and a local circuit, and the necessary current for the lamp being supplied by an independent set of batteries placed at each signal pole, where a lamp is suspended. All the apparatus required at each signal pole is a set of batteries, an incandescent lamp and a pair of small coils having an armature operating a pair of arms with pawls that alternately lock and release a geared wheel that throws the lamp into circuit.

Long-Distance Railway Work.

An idea of the great interest taken in the application of electricity to the propulsion of railway cars is clearly shown in the recent action of certain well-known railway officials in New Hampshire, who have contributed, it is reported, $12,000 to a fund to be used in defraying the expenses of carrying out a series of experiments in the hope of finding a suitable motor to displace the steam locomotives now in use on the short branches of the Concord & Montreal Railroad. As seldom more than one car is attached to the locomotive on the short branches the cost of operation is proportionately high, and it is in the hope of materially reducing the operating expenses that this fund has been set aside. The motor that will probably be the first in service is one de-

signed by Mr. J. F. Shawhan, of Detroit, who will superintend the operations, and is of a type similar to the Short motor, having a ring armature 18 inches in diameter and arranged for single reduction gear, or the gearless type will be used, as may be found desirable. The two field coils are built up of forged rings.

A New Water Motor.

The new Stilwell water motor shown in the accompanying illustration is the invention of H. C. Stilwell, of Dayton, O., son of the inventor of the famous Victor turbine water wheel. He has succeeded in producing a motor of very high efficiency. It is at the same time attractive, well designed, strongly and carefully built, simple and economical. The peculiar combination of two streams and the form of the buckets are ingenious and effective. One lever controls both streams, one or both or part of which may be used. The bearings are made of bronze and can be removed at any time should they become worn by neglect.

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

The Closing Quotations of electric stocks, from F. Z. Maguire & Co., electrical securities, 18 Wall street, New York, on Saturday, May 2, 1891, in New York, Boston, and Washington were:

Name of Stock.	Par.	Capitalization.	Bid.	Ask'd.
NEW YORK.				
Western Union Telegraph Co	100	86,200,000	82⅛	82⅝
American Telegraph & Cable	100	14,000,000	....	82½
Central and South American	100	5,000,000	145	160
Mexican	100	2,000,000	205	220
Commercial Cable Co	100	7,716,000	105	106
Postal Telegraph Cable	100	5,000,000	39	41
Edison General Electric Co	100	9,503,500	100	101½
" " Deferred	100	2,496,500	....	....
Consolidated Electric Light	100	1,929,400	....	....
Edison Electric Illuminating Co	100	2,567,800	76	78
United States Electric Light	100	1,500,000	30	31
North American Phonograph	100	6,200,000	....	....
BOSTON.				
Thomson-Houston Electric Co	25	6,000,000	47¼	47¾
" " preferred	25	4,000,000	25¾	26
" " Series C	10	400,000	9	9¼
" " Series D	10	120,000	7¼	7⅜
" International Co	100	1,000,000	....	....
Thomson Welding Co	100	1,000,000	....	....
" European Welding Co	100	1,000,000	55	60
Ft. Wayne Electric Co	25	4,000,000	13¼	13½
Westinghouse Electric Mfg. Co	50	5,000,000	15⅝	15¾
Telephone:				
American Bell	100	12,500,000	206	207½
Erie	100	4,800,000	50	50½
New England	100	10,504,600	52	....
Mexican	10	1,280,000	1	1.10
Tropical American	10	400,000	....	85c.
Edison Phonograph Doll	10	1,000,000	....	1
WASHINGTON.				
Pennsylvania Telephone	50	750,000	26	....
Chesapeake & Potomac	100	2,650,000	55	65
American Graphophone	10	600,000	5½	6¼
United States Electric Light (Washington)	100	300,000	167	175
Eckington and Soldiers' Home Electric Ry	50	352,000	54	55
Georgetown and Tennallytown	50	200,000	63	65

Chicago Quotations.—Col. S. G. Lynch, broker, 153 Monroe street, Chicago, furnishes quotations on telephone and electric light stocks as follows:

Chicago	$225@$245	Cumberland	$60@ $62
Central Union	56@ 57	Wisconsin	118@ 120
Michigan	85@ 86	Bell of Missouri	160@ 165
Great Southern	30@ 32	Iowa Union	20@ 22
Colorado	34@ 36	Missouri and Kansas	54@ 56
Rocky Mountain Bell.	40@ 43		

ELECTRIC LIGHT STOCKS.

Chicago Arc Light and Power	$105@$106	Chicago Edison Co	$145@$150

A Gold Scare.—This week has witnessed a selling market in general stocks. Gold shipments abroad have been the foundation of the change producing a scare which caused nearly everybody to run to the bear side. Electrical stocks have not suffered as the majority of railroad shares have; the rise last week was not great, but the market for the leading electrical stocks was steady all the week through.

Detroit Electrical Stock.—For a new stock these shares show remarkable activity. Investors show great confidence, and the future of the company looks very satisfactory. It is a good sign for the electrical business in general to see a comparatively new company come in and attain success at a jump. The business is getting too concentrated, and, while it is probably best for the large companies, it is perhaps much better to have business more divided. President Hugh McMillan said, concerning his company, that in 1890, on a capital of $200,000, it earned $50,000. He could not say that the rate of earnings to enlarged capital would be as large as last year, although the company had many orders on hand and in prospect. He thought a gross business of $3,000,000 per year on a capital increased to $1,000,000 was a conservative estimate. Mr. S. D. Loring said concerning the company that he found orders equal to $500,000 on hand when he inspected the works and accounts recently. On his way to Boston Mr. McMillan met a representative of the Pittsburgh syndicate which controls some 20 or more street railways in different cities, and was assured that the Detroit works should have the contracts to equip the railways of Fall River and Lawrence, Mass., and Buffalo, with the Rae motor and generators. These contracts Mr. Loring figured at $600,000, making over $1,000,000 of business immediately at hand. Mr. McMillan thought this a safe estimate. He said the company manufactured miscellaneous electrical apparatus, but the motor business had become the most important item. He said, when asked if it was true that he had received proposals to sell the Rae system to other companies, that the Thomson-Houston and Edison companies had tried to buy it. He could not say what future dividends would be. He believed in paying dividends, and the prospect for earning them appeared good. He said Boston would have two representatives upon the board of directors to be chosen at Detroit on Monday. As soon as he reached home he should give orders for enlarging the works. It would take about four months to complete this labor. The Detroit works were doing practically a cash business—that is, were not promoting companies and taking their stocks and bonds, but were doing a strictly manufacturing business and selling the products outright. The development of the electrical business seems to have reached a state which warrants a vigorous prosecution of business.

Westinghouse is having a good market, Brown, Riley & Co. have been large buyers of Westinghouse stock. People close to Westinghouse say that while all details in relation to present negotiations to establish Westinghouse finances on a solid footing are not complete, they still believe in a favorable final outcome. The annual meeting of the company occurs at Pittsburgh May 4, and it is said that Mr. Westinghouse hopes to be able then to make a full and satisfactory report as to the situation.

Erie Telephone Stock.—A prominent financial journal makes the following statement concerning the Texas syndicate matter: "It is understood that the arrangement entered into by the Erie Telephone Company with the Texas syndicate is in substance an option whereby the syndicate has the privilege of buying a portion or all of the stock of the Southwestern Company owned by the Erie. If a sale is made the proceeds will be divided in extra dividends among the stockholders. The terms are a cash payment for all stocks purchased except $50,000 worth, this to be 20 per cent. cash, balance at interest, payable in one year, secured by the stock as collateral. The Erie Company reserved during 1890 a cash surplus of $70,000, which, with a loan of $60,000, has enabled the company to take its proportion of the new stock issued in the sub-companies with the American Bell Telephone Company. The company has an underground plant covering the most important streets in St. Paul, Minneapolis and Cleveland and conduits in the same cities of 2,000 miles of wire. The new stock issued provided for this. A good authority on Erie telephone says: Judging the earnings of the company by the surplus earnings of the past nine months the Erie Company will add to its surplus for the fiscal year ending March 31, 1891, about $12,000, and the sub-companies $25,000, making the total surplus for the year $37,000. Seventeen thousand dollars of the $25,000 would be Erie's share, which with the $12,000 would make $29,000. At that rate the floating debt of the company, which amounts to $60,000 would soon be wiped out. The sub-companies have no indebtedness and can incur none without violating the American Bell contract."

The Phonograph Situation.—About five thousand shares of Phonograph stock are floating around for sale at low rates. Most of this stock can be had at about $5 a share. Upon the basis of what the phonograph cost to the North American Phonograph Company the stock would be worth at least $25 per share. The stock afloat was mostly issued for promotion and consequently is for sale low. It is hardly possible that persons who bought stock at $75 per share are going to sell at market rates. It is understood that several syndicates are after the property and desire to consolidate all the phonograph interests, reduce capitalization and push the business to the utmost. The writer thinks there is money in the enterprise and money in the stock, provided the business is properly pushed. The health of Mr. Lippincott, the president of the company, has been in such condition as to prevent his giving attention to the company, and, in plain language, the business has been neglected. If the new syndicate gets the property and pushes the business, stock will reach its old figures. F. Z. M.

AFFAIRS OF THE COMPANIES.

The Bridgeport (W. Va.) Electric Light and Power Company held a meeting last week, and elected George Summers, of Bridgeport, as president for the ensuing year.

The Hamilton Electric Light Company has been purchased from the Canada Permanent Loan and Savings Company, of Toronto, by a syndicate of Montreal, Toronto and Hamilton capitalists, for $92,000.

Bonds Issued.—The Brooklyn City Railroad lines have authorized the issue of $6,000,000 three per cent. bonds, $3,000,000 to be issued at once to retire outstanding obligations, and the balance to be held to equip the road with electric motive power.

The Citizens' Electric Light and Power Company, of Clifton Heights, Pa., the lines of which extend through Clifton Heights, Lansdowne, Burmont, Darby, Ridley Park and other neighboring towns, held its annual meeting last week and elected the following board of directors for the ensuing year: James S. Austin, James Garret and Edward V. Kane, of Lansdowne; John Frigar, of Yeadow; John Adams, Samuel L. Kent and Thomas Burwell, of Clifton Heights; Dr. J. W. Phillips, of Primos, and George A. Keyes, of Ridley Park.

NEW INCORPORATIONS.

The Niles (Mich.) Electric Company has been incorporated, with a capital of $40,000.

The Shaw Electric Crane Company, of Muskegon, Mich., has been incorporated with a capital stock of $50,000.

The Butler (Mo.) Water-Works, Light and Power Company has been incorporated with a capital of $100,000.

The Citizens' Electric Railway, Light and Power Company, of Mansfield, O., has been incorporated with a capital stock of $125,000.

The Coffer-Hampton Electric Company has been incorporated at Elgin, Ill., with a capital of $10,000, to manufacture electrical appliances.

The Peoria (Ill.) Electric Company has been incorporated with a capital of $100,000 to supply electric light. The incorporators are: Joseph Smith, Walter Barker and Israel C. Pinkney.

The Western Electrical Supply Company, of St. Louis, Mo., has been incorporated with a capital of $5,000. The incorporators are Charles Scudder, R. V. Scudder and T. J. Wilson.

The F. P. Morgan Power and Light Company, of Cincinnati, O., has been incorporated with a capital stock of $10,000. The company is to operate an electric light and power plant.

The Marshfield (Ore.) Edison Light and Power Company has been formed, with a capital stock of $30,000. C. W. Tower, L. C. Garrigas and J. D. Garfield are the incorporators.

The Ward T. Smith Company, of Tacoma, Wash., has been incorporated by W. T. Smith, W. S. Temple and Helen L. Smith, with a capital of $100,000. The company will construct telegraph and telephone lines, etc.

The Santa Fe (N. M.) Edison Electric Company has been incorporated by Joseph S. Decker, W. A. Williams, Edward Eads, W. S. Perry, Otto Lawgarden, H. E. Lord, C. A. Spofford, L. R. Kidder, H. N. Curtis, C. E. Reckerson, J. S. Williams.

The Harvey Electric, Water and Gas Company has been incorporated at Chicago, Ill., with a capital of $100,900, by Horace H. Badger, Charles D. Starwood and Willets G. Wanzer. The company is to operate water-works and a gas or electric light plant.

The American Investment Company, of Tacoma, Wash., with a capital of $10,000, has been incorporated by E. N. Castillo, C. E. Earl and S. L. Rau. The purpose of the company is to deal in franchises, motors and electric roads, telegraph and telephone lines, etc.

The Maxstadt Electric Company, of Chicago, Ill., has been incorporated to manufacture and sell electric fuses, compounds and other electric devices. The capital stock is $100,000. The incorporators are: Francis W. Maxstadt, Charles S. Cleaver and William L Marston.

The Highland Park and Fruitvale Electric Railroad has been formed in Oakland, Cal., recently. At the meeting of the City Council, Mr. Sessions and his associates, who have formed the corporation, secured a franchise to build an electric street railroad. The capital stock is $500,000.

The Arc and Incandescent Light Company, of San Francisco, Cal., has filed articles of incorporation. The capital stock is $1,000,000, of which $25,000 has been subscribed by the following directors: J. P. Martin, F. M. Pickering, Augustus J. Bowie, Louis T. Haggin, and Irwin C. Stump.

The Creaghead Engineering Company, of Covington, Ky., has been incorporated, with a capital of $25,000, by Thomas J. Creaghead, H. D. Emerson, C. L. McCrea and others. The company is to establish a factory for the manufacture of electrical supplies and appliances, and is to carry on a general engineering bureau.

The Dillon (Mont.) Power and Light Company has been incorporated with a capital stock of $20,000 by J. H. Lawrence, Allan Wheeler and Albert S. Hovey, and they are also named as the directors who will serve for the first three months. The company is to furnish electric light and power (electric and steam) to the town of Dillon, Mont.

The Potomac Electric Company, of Washington, D. C., has been incorporated by Joseph C. O. Gorman and Michael O'Donnell, of Stillwater, Minn.; H. P. Gilbert, G. Hill, Jr.; G. W. Laird and Neill Dumont, to produce electricity for use as a motive power or for illumination. The capital stock is $25,000 in shares of $100 each, with privilege to increase to $500,000.

The Northwest Electric Engineering Company has been formed in Portland, Ore., by H. W. Schultz, A. W. Tobin and Edward Cannon as directors. The capital stock of the corporation is fixed at $40,000. The principal place of business is in Portland, and the object of the corporation is to deal in electric plants for motive power, heat and light; also to do a general supply business.

The Newport News (Va.) Electric Light and Power Company has been organized with the following officers: President, E. C. Hillger; vice-president, L. P. Stevens; secretary, W. W. Archibald; treasurer, Geo. A. Schurelz. The directors are: C. M. Braxton, J. B. Jennings, R. G. Bickford, D. S. Jones, T. H. Gordon. The company proposes to furnish light for the city and current for propelling street cars, etc.

The Union Power Company, of Portland, Ore., has been incorporated with J. B. Hammond, P. F. Morey, C. F. Swigert, George B. Markle, D. F. Sherman and H. C. Campbell as directors. The capital stock is $150,000, divided into 1,500 shares. The object of the company is to furnish electricity for all purposes in Portland, East Portland and Albina, Cal. The power house will be furnished with a 3,000 h. p. power plant.

The Instantaneous Fire Alarm Company, of Buffalo, N. Y., has filed articles of incorporation. The corporation is formed for the purpose of erecting poles, wires and devices necessary for the purpose of telegraphing in conjunction with the fire alarm system of the city, or independently thereof, alarms of fire from various houses and buildings of the city to various engine-houses and places where fire companies may be stationed. The capital stock is $50,000. The following are the incorporators: Philo D. Beard, Henry Altman, Jacob Stern, Thomas T. Ramsdell, and John J. Griffin.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-177 TIMES BUILDING, NEW YORK, May 4, 1891.

Messrs. Reed & McKibbin, of New York, have just closed a contract for 11 miles of street railway that is to be equipped electrically at once. This firm is now occupying its new quarters at 2 Wall street.

Mr. C. J. Ferguson, who has been connected with the advertising department of *Electric Power* since the establishment of that perodical, has resigned, and will accept a similar position with the *Journal of Railway Appliances*, New York City.

Mr. A. E. Groetzinger, secretary of the Chas. Munson Belting Company, of Chicago, was in New York during the last few days, and received a warm reception from his many old friends. The Munson company has just sold a 72-inch belt to the St. Louis and Suburban Railroad, St. Louis, Mo.

Mr. Alva Oatman, formerly with Pratt & Whitney, of Hartford, Conn., has joined forces with Messrs. W. R. Fleming & Co., of New York City, and will represent them generally throughout the country. Mr. Oatman has a large acquaintance in the electrical field, and will be a valuable acquisition to the force of Fleming & Co.

Mr. Edward C. Kilbourne, vice-president and general manager of the Home Electric Company, of Seattle, Wash., is in New York City spending a few days on business connected with the financial developments of his company. He reports a very prosperous business in that section of the country. His company has recently refused orders for a large number of lights on account of the inability of the station to supply them.

The Magnetic Club, which was organized April 19, 1888, sat down to an annual dinner on Wednesday evening of last week at 878 Sixth avenue, in this city. Sixty-five members and friends were in attendance to enjoy the festivities of the occasion. Mr. Cockey presided at the head of the table, and introduced the various speakers of the evening in a very happy manner. "Judge" Greene gave some very enjoyable recitations in his usual excellent style. Several songs were rendered by the club's quartet, besides instrumental solos, etc. The club is in a prosperous condition, and its annual dinners are a decided success.

Mr. Park Benjamin delivered a very interesting address before the American Society of Mechanical Engineers in this city last Thursday evening, on the history of electricity prior to the time of Galvani. The lecture was accompanied by lantern views of early publications containing reference to electricity. Among these were the publications of Robert Norman, of Gilbert, of Boyle, Stephen Gray, and many other early writers on the subject of electricity and magnetism. The lecture was an entertaining one, and was very much enjoyed by the mechanical engineers and the large number of ladies who were present.

Electric Club Report.—The financial statement of the retiring president of the Electric Club, Mr. O. E. Madden, makes an excellent showing for the organization. On Oct. 31, 1889, when Mr. Madden took the presidency, there was a deficiency of nearly $7,500; on March 31 last the club had a surplus of nearly $3,700, and everything now points to a prosperous future for the organization. The club has 167 active, 124 associate and 17 life members, or rather it had that number before the last 30 new members were elected. The temporary reduction of the initiation fees for both active and associate members is working nicely, and it is probable that it will end at the expiration of the appointed term of three months in adding something like 150. L. H. H.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 28, Hathaway Building, 620 Atlantic Ave.,
BOSTON, May 2, 1891.

Mr. Norman Marshall, president of the Star Electric Company, was in town this week on a business and pleasure trip.

Messrs. B. S. Hale & Son are very busy filling several large orders for their insulated wire, which is so favorably known to the trade.

The Redding Electric Company has been appointed New England agent for the Star Electrix specialties, but inasmuch as

the former agent, Mr. H. M. Nichols, goes along as manager of one of the departments of the Redding Company, the change will prove beneficial all around.

The New England Printing Telegraph Company is still having trouble with the Boston authorities in regard to permits for the erection of pole-lines. Last week the company, through its attorneys, I. R. and W. S Clark, presented a petition for a writ of mandamus requiring that the above permission be granted.

The New England Engineering Company is now occupying its new building at Waterbury. The main floor is devoted to offices, drafting rooms, etc., and the others to supplies, etc., used in the company's large and growing business The new electric railway now being installed in Johnson City, Tenn., by this company is nearly ready for operation.

Bridgeport, Conn.—Owing to increased business the Star Electric Company has moved to 69 State street, its new quarters. This company operates the Bridgeport office of the Postal Telegraph Company and Bridgeport District Telegraph Company. Mr. C. D. Miller, of the Star Company, has been very sick for the last few weeks, but is now recovering rapidly.

Redding Electric Company's Building Damaged.—There was a fire last week in the building, 48 Hanover street, in which is located the Redding Electric Company. The company sustained considerable damage from water and smoke, the latter very slight. It was thought at one time that the building and contents would be a total loss, which happily proved otherwise.

The Economic Electric Company has many orders still unfilled, though it is now turning out 1,000 lamps per day. The following agents have been appointed by this company: Pettingell & Andrews Co. for New England, Charles L. Edlitz for New York State, Vallee Brothers for Philadelphia and vicinity, and the Northwestern Specialty Company for Chicago and the Northwest.

Mr. Frank Wheeler, of Meriden, Conn., inventor of the well known trolley of that name, was in town last week, and reports business good. He has just filled a special order for the Baldwin Locomotive Works, of Philadelphia, which company uses it on its immense traveling cranes, which are of the largest capacity of any in the world. Surely the indorsement of such a company is good evidence of the worth of the trolley, as this is a second order from the latter company.

Boston's Illumination.—In the Senate, the adverse report on the petition of the Common Council of the city of Boston, that the city be given authority to construct and maintain its own gas and electric light plant, coming up for acceptance, it was remarked that nobody appeared in favor of the petition, and that it was well known that the City Council of Boston was divided upon the matter. Mr. Coveney, who had moved a postponement, withdrew his motion after this explanation, and the report was accepted.

The Consolidated Motor Company, of this city, is fitting up a commodious factory at 260 Dover street, and furnishing it with special tools for the manufacture of its new motor. When completed this factory will be one of the finest shops of the kind in the country. Mr. A. B. Holmes, formerly with the Consolidated Electric Company, has been appointed mechanical superintendent of the company, and Mr. J. Edward Carter has been elected treasurer and will undoubtedly prove a great acquisition to the company. The Consolidated Motor Company has many advance orders for new motors.

Trade in New England.—There is a better feeling generally in all branches of the electrical trade throughout New England. New factories are being built, old ones are enlarging, and it is generally conceded by those in a position to know that this revival is not merely a spasmodic brightening up, but that it has come to stay. The great trouble in the past in this trade has been the system of long credits demanded and allowed, the fallacy of which has been fully demonstrated during the past few months of depression and slow collections. Now with the orders coming from Europe, South America, Mexico and Canada, in addition to the home trade, and with easy collections, manufacturers and dealers are beginning to prepare for their summer outing. C. A. B.

PHILADELPHIA NOTES.

Branch Office of The Electrical World,
31 City Trust Building, Philadelphia, May 2, 1891.

The Globe Electric Cordage Works reports a very satisfactory business with its "Oehrle" patent fire and waterproof cord, a specialty of the company.

Messrs. Clay, Pepper & Register, a new firm of electrical engineers, have removed their office from 1,218 Filbert street to 603 Provident building.

The Frankford Electric Light and Power Company, which recently sold its franchise to Mr. C. B. Porter and others, has advertised for sale its entire plant except the poles and boilers.

Messrs. Henry Major and E. S. Morrell, formerly with the Novelty Electric Company of this city, have established an electrical supply house at 934 Ridge avenue. They will also do electrical contracting.

Chester, Pa.—The South Chester Electric Light and Power Company, the plant of which was recently destroyed by fire, is rebuilding, and has contracted with the La Roche Electric Works, of Philadelphia, for a 600 incandescent and a 20-arc light machine.

Baltimore, Md.—Messrs. Kingsbury and Mustard, a firm recently established at the Neal building, will carry on a general electric construction and supply business. Mr. Lester L. Kingsbury, of the company, was formerly manager of the North American Construction Company, and Mr. John Mustard was acting as superintendent of the latter company.

The La Roche Electric Works is doing as great a business as the present increased facilities will allow. The company reports the following recent installations: One 5 h. p. motor for the *Sunday Mercury* Company; one 3 h. p. motor for S. Lubin; one 3 h. p. motor for M. Mendlesohn; one 3 h. p. motor for M. Silverstein; one 2-arc light dynamo for P. Fest, of Germantown; 6 motors ranging from 1 to 2 h. p. for the Frankford Electric Light and Power Company; one 500-light machine (an increase) for the Devon Electric Light and Power Company; one 500 incandescent light, 50 arc light machines and three small motors for E. I. du Pont de Nemours & Co., of Wilmington, Del.; one 150 light plant for J. K. Rishl, of Hughesville, Pa., and one 50 light plant for the Bay Jou Plantation, of Jennietteville, La.

Wire Regulation in Pittsburgh, Pa.—Two ordinances have recently been passed by the Pittsburgh councils, which are to bring the wire-stringing companies under the same regulations as those of New York City. The first ordinance provides that after July 1, 1892, all wires and poles within the urban district of the city shall be removed, and that should the order not be complied with, the chief of the department of public works will be empowered to remove the lines without further notice to the owners. The second ordinance has reference to underground wires, and provides that all those companies which have complied with the order of the first ordinance before the date named shall have rights of way to lay subway circuits in the principal streets of the district named. The ordinances in no way refer to overhead trolley wires of street railways. W. F. H.

WESTERN NOTES.

Branch Office of The Electrical World,
465 The Rookery, Chicago, May 2, 1891.

The Western Electric Company, of Chicago, will wire the new Temple building, now in course of erection, for 3,600 incandescent lamps and for all bell work, etc.

Mr. George P. Shaw, general manager of the National Electric Manufacturing Company, Eau Claire, Wis., and his affable superintendent, Mr. C. Kammeyer, were in Chicago for a day last week.

Mr. Herbert Wadsworth, manager of the Chicago office of the Excelsior Electric Company, has recently sold one 15-light and one 30-arc light Excelsior dynamo and three 100-light Excelsior arc dynamos, complete.

The Interior Conduit and Insulation Company will remove its western office from the present location, 1,105 Owing Building, to 435 The Rookery, at once, Mr. H. M. Underwood continuing as the general Western agent.

Mr. Ernest L. Burrell, manager of the Chicago office of Messrs. C. A. Schieren & Co., has recently sold one 24-inch double perforated electric belt and several small belts for street railway work, and a perforated electric belt to the Petoskey (Mich.) electric light company.

Mr. George L. Kirkham, Chamber of Commerce, Chicago, is already the recipient of several large orders for incandescent lamps that are a substantial endorsement of his ability to impress on the attention of the central station manager the admirable qualities of the Economic lamp in the matter of extreme brilliancy with minimum consumption of current.

Mr. Franklin G. Beach, general superintendent of the Central Union Telephone Company, Chicago, in referring to the large number of telephones installed last month, nearly 400, says that the call for additional telephone facilities generally indicates a prosperous season for general business circles in the smaller cities, and at the rate instruments have lately been placed in business houses and residences, at least 5,000 new telephones will be in service before the year ends, showing that even in the smaller towns telephone communication is no longer a luxury, but a necessity. F. de L.

SOUTHERN NOTES.

Norfolk, Va., May 2, 1891.

Leesburg, Va., is preparing to install a system of incandescent electric lights.

Mineola, Tex., is negotiating for the establishment of an electric light plant.

Bardstown, Ky.—Mr. A. R. Caruthers is interested in the erection of an electric light plant.

Lynchburg, Va.—The track of the new electric street car line has been completed, and the cars make a trial trip this week.

Long View, Texas.—Negotiations are pending for the establishment of an incandescent electric light plant to have 300 lights

Aiken, S. C.—A contract has been awarded the Carolina Light and Power Company for the establishment of an electric light plant.

Attala, Ala.—A contract has been awarded to Messrs. Hartford, Herbert & Co., of Chattanooga, Tenn., for the erection of an electric light plant.

Newnan, Ga.—The city council has entered into a contract with L. W. Cox, of Washington, D. C., for the establishment of an electric light plant.

Chattanooga, Tenn.—The Chattanooga Electrical Street Railway Company is preparing to issue $250,000 of bonds for improving the street railway system.

Houston, Tex.—The Houston Rapid Transit and Suburban Electric Railway Company is the name of a new corporation recently formed by Denver parties to construct and operate an electric line here.

South Pittsburg, Tenn.—The capacity of the electric light plant of the South Pittsburg Electric Light and Power Company is to be increased, and that company is now in the market for the additional machinery.

Charleston, W. Va.—The City Electric Light Company, with a capital stock of $50,000, has been incorporated by Cleon Moore, D. D. Gibson, P. C. Kennedy, and others, and an electric light and power plant will be established.

Norfolk, Va.—The Southern Branch Investment Company, with a capital stock of $50,000, has been incorporated with L. H. Shields, and G. W. Taylor, secretary. The charter of this company grants the privilege of erecting an electric light plant.

Atlanta, Ga.—The Gamewell Fire Alarm Company, of New York City, is the contractor for the Atlanta municipal signal system. This system is to cost $10,000. It was incorrectly stated recently that another company had received the contract. V. N. B.

Answers to Correspondents.

Questions to be answered in this column must be of general electrical interest, and must be accompanied by real name and address as a guarantee of good faith. No notice will be taken of questions regarding apparatus unless enough details are given to permit a definite answer, and no dynamo or motor designing will be done.

Cementing Glass.—Will you kindly give me a formula for making some cement for attaching the bottoms of incandescent lamps to the bulbs? A. C. T.

United States Patent No. 345,542 of July 13, 1886, describes a cement for securing metal to glass, which is said to be especially valuable for the purpose you state.

Alternations and Periods.—In Vol. XVI, p. 40, Electrical World, under "Measurement of Self-Induction," does "complete alternation" mean a complete period? and does the "number of alternations per second" mean the number of such complete periods? I ordinarily understand the latter to mean twice the number of complete periods. Subscriber.

Complete alternation means a complete period, as you understood it.

Accumulators and Motors.—(1) Please inform me how many storage battery cells it will take to run a half horse-power motor? (2) What is the most economical accumulator? (3) What is the cost of a good half horse-power motor? J. P.

(1) The question is vague. It depends upon the voltage and current required by the motor what the number of cells will be, and also upon what size cell is used. (2) We cannot name any particular make of accumulator as the most economical to use. (3) The cost of a half horse-power motor is usually between 60 and 80 dollars.

Flickering Lights.—I have two 110-volt dynamos running direct from one engine. The lights on one machine are perfectly steady, but those in the circuit of the other are constantly flickering. What is the cause? W. K. S.

See that the belt driving the troublesome dynamo is as it should be—that it drives the armature with a steady rotation. Then begin at the switchboard or the farthest part of the circuit which is subject to vibration from the machinery or other causes and *examine all connections* to see that they are tight and firm. Examine the circuit past the terminals of the dynamo, and see that all the armature wire connections to the commutator strips are firmly joined with solder. If no loose connections are found in the circuit, see that your brushes are properly trimmed and placed. Possibly your commutator is rough and needs turning down and polishing.

Coupling Transformers.—Will you please inform me through your correspondence column what would be the effect of connecting three transformers with the primaries in multiple arc and the secondaries in series with each other? How would it affect the current and electromotive force? How.

The result of the coupling you describe would be the addition of the voltages of the three transformers, provided, of course, the induced electromotive force were in the same phase. The consumption of current in the primaries would be practically the same for the same energy developed in the secondaries as if the latter were used separately. In order that the three transformers should work together in harmony the currents should be in the same phase. This condition is not generally easy to secure, and in trying the experiment it is more than probable that you would find one or more of the transformers heating seriously. However, if they are precisely alike, so that the induced currents are virtually superimposed and in very nearly the same phase, the arrangement will work fairly well. We would not advise you to try it except in an experimental way, on account of the difficulty mentioned.

News of the Week.

THE TELEGRAPH.

San Francisco, Cal.—The Highland Springs and Squaw Creek Toll Road Company will build a telegraph and telephone line through Lake county.

The Anglo-German Cable.—A plan has lately been formed for laying a cable between England and Germany. In spite of the close interests of the two countries, there has hitherto been no direct means of communication between them; but two officials of a German port were in London recently, consulting for the carrying out of the project, which is now considered as having been definitely settled.

New Pennsylvania Lines.—The Postal Telegraph Company is about to establish branch offices in all towns in the coal regions of Pennsylvania where the lines do not now reach. A line will be extended from Wilkesbarre to Hazleton over the turnpike, and from Hazleton to Bloomsburg, Catawissa, Danville, Ashland, Mahanoy City, Shenandoah and Pottsville. A loop will be run from Mauch Chunk to Tamaqua, while another line will be sent up from Reading northward.

THE TELEPHONE.

Missoula, Mont.—Mr. J. M. Carnahan, manager of the new telephone exchange, in his first day's canvass, last week, secured 64 subscribers to the exchange. The new exchange will open within 30 days with about 150 instruments.

New Jersey Telephone System.—A change is announced in the New Jersey telephone system, by which Mr. John F. Noonan will retain his position as manager of what is known as the Paterson district. Mr. R. Clark will be assistant, with headquarters at Passaic, while Mr. G. Massaker will officiate in a similar capacity at Dover. Miss Gertrude Paul will be chief operator of the whole district, and Messrs. J. W. Esther and F. Arrison have been appointed district inspectors and will devote their time and attention exclusively to that branch. Among the duties of the latter will be to visit each subscriber, to receive complaints and ascertain any delinquencies in the transmission of messages.

New Haven, Conn., Telephone Rates.—When the telephone exchange in New Haven was first established, telephones in business offices were rented for $40 per year. As the exchange grew, an increased price was charged new subscribers, but the old rate was maintained with the early patrons. An order of April 1, however, changes all this, and already 22 telephones have been taken out, most of them from business offices where the proprietors refused to pay the increased rate. The present rates are $50 a year for all telephones in business places which are on the circuits of several instruments, $75 a year for the single ground circuit and $125 a year for the metallic circuit with long distance instruments.

THE ELECTRIC LIGHT.

Camden, N. J.—The electric light company is making extensive additions to its plant.

Modesta, Cal.—The incandescent electric light plant was successfully put in operation last week.

Anderson, Ind.—Messrs. Bosworth and Poling are installing a 1,000-light incandescent plant for supplying commercial lights in the above town.

Georgetown, Col.—The electric light company has commenced the erection of its buildings, and promises to have its plant in running order early in May.

San Diego, Cal.—The Board of Public Works has been instructed to award the contract for lighting the city to the San Diego Gas and Electric Light Company.

Beverly, Mass., has made a 10-year contract with a local company to light the streets until midnight with 82 electric lights, each 1,200 c. p., for 30 cents per light per night.

Moundsville, W. Va.—The Moundsville Electric Light Company has been awarded the contract for lighting the Moundsville Camp Grounds for a period of five years.

Mason City, Ill.—Messrs. J. B. Abbot & Son have purchased the arc light plant of the city, and are receiving bids for the apparatus and steam plant for an alternating current plant.

St. Ignace, Mich.—The mayor has sent a message to the city council, recommending the establishment of an electric light plant, and urges the committee to investigate the costs of such an enterprise.

San Francisco, Cal.—An order was passed last week granting the Electric Improvement Company permission to erect poles and

wires throughout the city for conveying electricity for power and for illuminating purposes.

The Reno (Nev.) Electric Light and Power Company has decided to build a suspension bridge across the Truckee River to the site recently purchased by the company. Work will also be commenced on the new building for the electric light plant. This plant has been a paying one from the start and has already made several additions.

East Orange, N. J.—The contract for lighting the streets of East Orange with gas will expire on May 31, and the question is being discussed whether it shall be renewed or whether the example of the city of Orange shall be followed and the streets be lighted with arc lights. Both systems have supporters, but it is likely that electric light will be adopted.

Vallejo, Cal., will receive sealed proposals until May 15, 1891, for lighting the public squares and streets of that city with 30 or more 2,000 c. p. single arc electric light lamps, the contract to be for a period of five years from date of lighting. To the successful bidder a charter privilege for a period of 10 years will be granted for the purposes of private and commercial lighting with the incandescent and arc systems.

Greenwich, N. Y.—The Electric Construction Company has issued to the Board of Trustees a proposition for street lighting which is understood to be as follows: The company will light the streets of the village with 30 arc lights, on moon schedule, with the privilege to the Trustees of ordering the lights on cloudy moonlight nights, for $1.525 per year, providing the Board of Trustees will grant a contract for a term of five years.

Milwaukee, Wis.—The committee on street lights has voted favorably on a resolution instructing the Board of Public Works to advertise for bids for lighting the streets with electricity by overhead and underground conduits for a term of three or five years. It is thought that by awarding a contract for a longer term cheaper lights will be secured The city now pays $112.50 per arc light. The contract with the Badger company will expire next summer.

Louisville, Ky.—The new electric light plant of the Louisville Gas Company, now being constructed, will, it is said, be the largest of the kind south of the Ohio River. It is being built under the direction of Hite Barrett, chief engineer of the gas company, and Architect Drach. The massive foundations for the power-house and the smoke-stack are now above ground, and the building will go up rapidly. It is likely before the fall months Louisville will have as good electric light facilities as any city in the country.

Woodhaven, N. Y.—The Buckhout Electric Light Company proposes to establish a plant in Woodhaven for the purpose of lighting that village and Ozone Park, N. Y. In May, 1890, the commissioners of highways of Jamaica granted the company permission to erect poles along the public streets on its giving an indemnity bond and agreeing to begin operations within one year. The company has now taken its first step under this agreement by scattering poles along the thoroughfares and sending men to place them in position.

Covington, Ky.—At a meeting of Council, the Covington Electric Light Company made a proposition to furnish light to the city for a period of 25 years. The lamps are not to be more than one square apart. The company offers to furnish them at $8.25 on the moonlight schedule plan, the company to do all lighting and repairing, and to place in each gas shade an incandescent light at $20 a lamp for a year, to burn all night, or $18 a lamp under the moonlight schedule. It also offers special rates to light the public buildings.

Toronto, Can.—Under the guidance of Messrs. Fred Nicholls, manager; W. E. Davis, superintendent, and A. E. Anderson, assistant superintendent, of the Toronto Incandescent Electric Light Company, a party of visitors were recently piloted through the premises and examined the many interesting features of the machinery. In the basement were eight Edison dynamos, six of 1,000 16 c. p. lights and two of 2,000 lights, these latter being the largest in the Dominion. These supply 17 miles of underground wires already in operation, and arrangements are completed for laying 10 additional miles this summer. The Armington & Sims high-speed engines, one of 175 h. p. and one of 300 h. p., and two Straight Line engines of 175 h. p. each, run the dynamos, the largest of these giving 260 revolutions per minute. In the boiler room are seven return tubular boilers of 125 h. p. each, built by the John Doty Engine Company, of this city. The buildings are at present only partially completed, but when finished will be a handsome block of five stories and basement, in red brick, with stone facings.

THE ELECTRIC RAILWAY.

Victoria, B. C.—The Electric Tramway Company has begun the work of construction on the new line to Oak Bay.

Oakland, Cal.—Dr. Addison has sold to the Oakland & Berkeley Rapid Transit Electric Road four cars, equipped with eight of the new Thomson-Houston slow-speed motors.

Portland, Ore.—The Transcontinental Street Railway Company will change its road to an electric system. Mr. B. F. Stewart, of the Westinghouse Electric and Manufacturing Company, is negotiating with the former company with regard to equipping the road.

San Francisco, Cal.—Irwin C. Stump, Abner Doble, W. R. Hearst, William Hollis and others have filed an amended petition for a franchise to conduct an electric railway in the city. The petitioners ask permission to propel cars by electricity, but in order to conform to a general ordinance passed recently agree not to erect poles, or to use any system requiring overhead wires.

Pittsburgh, Pa.—Mr. Murray Verner, general manager of the Pittsburgh and Birmingham Traction Company, says that the line will be in operation toward the end of May. The road will start with the use of 10 Sprague and 20 Short equipments. This road forms a part of what is known as the Sellers McKee Railway syndicate, and it is stated that the several lines of the above syndicate will use at least 1,300 cars. As yet it is not decided what motor will be used throughout, but it is most likely that either the Edison company or the Short company will receive the contract, as it is expected that the test of the motors of these companies, now on the road, will prove satisfactory.

A Safety Device for Trolley Wires.—A piece of apparatus for rendering safe the ends of a broken trolley wire was recently tested in Boston. It consists of a frame, a parallelogram in shape, the space between the sides being occupied by a spiral spring which operates a contact bar. Inside of the parallel sides, thoroughly insulated, run the wires connecting with the contact piece of brass. In operation the strain of the wire pulls the contact bar, which is connected with the spiral spring, into contact with the brass contact piece, and electric connection is secured. When the wire breaks the strain is released, the contact bar springs back, and all wire beyond the device is "dead." Max Kerstein is the inventor.

LEGAL NOTE.

Brush Injunction Denied.—Judges Pardee and Billings, of the Federal courts in New Orleans, La., last week denied the injunction sought to be obtained by the Southwestern Brush Electric Company against the Louisiana Electric Light Company and the Brush Electric Light Company. It was decided that as the double-carbon lamp was of immediate necessity to the public safety and convenience, its use by the two latter companies could not be enjoined on preliminary hearing.

PERSONAL.

Mr. Wilbur W. Joy has just resigned his position as superintendent of the rolling department of the Bridgeport (Conn.) Copper Company and accepted the position of metallurgist and consulting engineer of the company exploiting the Hayden process of the electro-deposition of metals. He is under contracts with the above company and the Baltimore Electric Refining Company. For the year to come he will reside in Baltimore as superintendent of the entire plant of the latter company.

MISCELLANEOUS NOTES.

Electricity in Japan.—A dainty pamphlet has recently been received from Tokyo, Japan, which is devoted to a description of electrical industries in that country.

The Royal Society of Canada is to hold its annual meeting this year in Montreal, on May 27. Heretofore the meetings were held in Ottawa. A most complete hand book of the history, rules, etc., etc, has been issued from Montreal, and will be of great service to visitors to the May convention.

Industrial and Trade Notes.

Messrs. Truex & Vail are now in their commodiou quarters in the new Electrical Exchange building in New York City.

Mr. John L. Moore has resigned his position as representative of the National Electrical Manufacturing Company, of 14 and 16 Vesey street, New York City.

The Electrical Supply Company, of Chicago, the Western agent for the Habirshaw wires and cables, has recently shipped a very large order of this wire to Salt Lake City, Utah.

James Schawel & Co., importers and melters of platinum at 29 John street, New York, have just received a new stock of French lamp wire of an especially fine quality in numbers from 26 to 30 B. & S. gauge.

Mr. George Cutter, of Chicago, reports steady sales of his pulley for arc lamps, which is being used exclusively in some new plants, while in other places it is replacing the old styles of pulleys formerly used.

The Interior Conduit and Insulation Company, of New York city, has issued a pamphlet descriptive of its multiple and single duct systems of underground conduits. The pamphlet is illustrated by a number of handsome cuts.

The Electrical Manufacturing Company, of Dayton, O., has issued a new catalogue of its large line of specialties. This company is the exclusive agent of the Fletcher appliances and fittings, and has always in stock Habirshaw wire, Sunbeam lamps and other supplies.

The Ball Engine Company, of Erie, Pa., has appointed as its New York agents Messrs. E. T Copeland & Co., of 106 Liberty street. Mr. Copeland's long experience in the sale of engines in New York gives assurance that the interests of the Ball company will be in intelligent hands.

The Automatic Electric Signal Clock Company, of Waynesboro, Pa., controls the patents on the McCaskey system of electrically controlled time. The above company has recently issued a pamphlet descriptive of the McCaskey electric programme clock for use in schools and business houses.

The Law Battery.—A letter was seen in the office of the Law Battery Company during the last few days from a prominent telephone company operating over several States, in which it was said that the company can scarcely get along without the Law battery. The orders received from this company amount to over 5,000 cells per year.

Messrs. Alexander, Barney & Chapin, notwithstanding the dullness reported among some other companies, have evidently been getting their share of the trade. During the last week they have been working in their packing department until 9 and 10 P. M. with increased force, one order alone for export taking two days to pack the goods called for.

Mr. B. S. Whitney, of 113 North Fourth street, Troy, N. Y., is manufacturing a special babbitt metal for dynamos, motors and high-speed engines. Mr. Whitney has been in the metal business for nearly half a century, and, as a result of long experience and many experiments has now placed upon the market a special brand of babbitt metal called the "A & A."

Mr. D. C. Siles, of Elmira, N. Y., has issued a "Circular C," which is descriptive of his steel railway poles, brackets and mast arms. The Siles metallic railway pole is of such a design as to resist the pull of the span wire without being heavy and unsightly, and, from the list of sizes and types furnished by Mr. Siles, poles to suit all possible requirements can be selected.

The Joseph Dixon Crucible Company, the well known makers of "Dixon's American Graphite" pencils, is always at the front in keeping the public informed of the various excellent grades of pencils of its manufacture. The above company has recently issued a beautiful card lithographed in nine colors showing a bundle of Dixon pencils of several different grades.

The Taylor Primary Battery, No. 2, has an ampère capacity of 22.5 ampères instead of 2.25, as the printer made the statement regarding this battery read in our advertising pages last week. The No. 1 cell of the Taylor manufacture gives 40 ampères, and has a capacity of 200 ampère hours, while the No. 2 cell, giving 22.5 ampères, has a capacity of 80 ampère hours.

The Schultz Belting Company, of St. Louis, Mo., has just closed a contract with the St. Louis and Suburban Railroad Company for two 72-inch belts, each 154 feet long, and 10 belts 16 inches wide aggregating 700 feet in length. All of these belts are to be made double leather and to be cemented. The company has also secured many other orders lately for its "electric dynamo" brand of belting.

Lloyd & Paxton is the name of an enterprising firm that has opened offices at 2 Wall street, and proposes to have a go at the storage battery business. The firm includes gentlemen of no little experience in that line, and has not the most wonderful invention of modern times, giving 4 volts at 200 per cent. efficiency—it just proposes to put a thoroughly good storage cell on the market at a reasonable price.

Mr. I. P. Frink, manufacturer of the well known "Frink" reflectors, has recently made installations in the following churches: Grace P. E. Church, Watertown, N. Y.; M. E. Church, Dover, N.J.; M. E. Church, Danbury, Conn.; Swedish Lutheran Church, St. Paul, Minn.; First Congregational Church, Olean, N. Y.; M. E. Church, Suffolk, Va.; M. E. Church, Huntington, W. Va., and the M. E. Church, South Harrisonburg, Va.

The Electric Railway Specialty Company.—Mr. P. H. Carey, secretary, and Mr. C. D. Mayer, traveling agent for the Electric Railway Specialty Company, covering the northern and southern portions of the country, respectively, report an active demand for their Nuttall trolleys, wooden gears, metal gears, etc. This company is getting out a number of new specialties. Their new offices at 29 Broadway will be occupied during May.

The Washburn and Moen Manufacturing Company, of Worcester, Mass., is to have in its immense wire factory, which is being erected in Chicago, Ill., a room which will contain two lines of the Evans friction cone pulleys of 75 h. p. each. Each line will contain 12 sets of 6 h. p. cones, with the driving cones coupled together, making the two continuous lines of 75 h. p. each. Each set of these cone pulleys gives a variation of from one to nine, and the speed can be changed or any cone can be stopped while the main line is running.

The Standard Electric Time Company, of New Haven, Conn., has recently made some new and important improvements in its "Warner's Gauge," making it stronger, and, if possible, more reliable. The company have also just completed a new self-winding clock that is a model of simplicity. The new catalogue now in the hands of the printer will be larger and more handsome than ever, containing many novelties. The present facilities of this company have become inadequate, and the present offices and battery rooms are to be removed to additional quarters rented in the same building. The old offices and battery rooms will then be used as a part of the workshop.

The Fitchburg (Mass.) Engine Company has just closed contracts for its engines and machinery with the following: Complete equipment of engines, shafting, etc., for the W. C. T. U. Temple in Chicago; a compound engine for the Arnold Print Works, North Adams, Mass.; a compound engine for the Brattleboro (Vt.) Gas Light Company; a complete outfit, including large engine, boilers, etc., for a brass plant in Virginia; a large engine for the morocco factory of Paschall, Lichten and Lyon, at Frankford, Pa.; an engine for Messrs. Barnes and Bever, of Philadelphia; an engine for the Tubular Rivet Company of Wollaston Heights, Mass; an engine for the Sockanosset School for Boys, Howard, R. I.; an engine for the Revere Rubber Company, Boston, Mass.; an engine for Three Rivers (Mich.) Paper Company and an engine equipment for Chicago.

E. G. Barnard & Co., electrical and mechanical engineers, have established an office and electrical supply store at 7 First street, Troy, N. Y., where the firm is now prepared to undertake electrical work and supply electrical material, fittings and appliances of every description. This firm is composed of Mr. E. G. Barnard, formerly with the Sawyer-Man, United States and Westinghouse Electric companies, and Mr. W. D. Weaver, late assistant engineer U. S. Navy, who is well known to electrical men in New York city. Both gentlemen are members of the Institute of Electrical Engineers. Since the organization of the firm on February 1 last 12 plants have been installed and contracts are signed for many more, among them an accumulator plant for a country residence. In the dry goods store of A. M. Church & Co., of Troy, two U. S. dynamos, one for 20 arcs and one for 50 incandescents, have been placed, with driving engines, in a space only 7 × 10 feet. Westinghouse engines and Evans friction cones are used. Mr. Barnard has had an experience of 11 years in the electrical business, and in that time has acquired a vast amount of practical knowledge of installation work.

Messrs. McIntosh, Seymour & Co., of Auburn, N. Y., builders of compound engines, have received the following orders for engines recently: two 500 h. p. double compound tandem railway engines for the Georgia Electric Light Company, of Atlanta, Ga.; two 400 h. p. standard compound railway engines for the Brooklyn City Railway Company, of Brooklyn, N. Y.; two 400 h. p. standard compound railway engines for the Baltimore Electric Refining Company, of Baltimore, Md.; one 300 h. p. standard compound railway engine for a street railway in Long Island City, N.Y.; two 200 h. p. standard compound railway engines for an electric railway in Rio Janeiro, Brazil; one 400 h. p. standard compound railway engine for the East Side Railway Company, of Brocton, Mass.; one 200 h. p. standard compound engine for the Auburn City Railway Company, of Auburn, N. Y.; two 200 h. p. standard compound railway engines for an electric railway in Fall River, Mass.; one 200 h. p. standard compound railway engine for the Merrimac Valley Street Railway Company, of Lawrence, Mass.; one 150 h. p. standard compound railway engine for the Merrimac Valley Street Railway Company, of Lawrence, Mass.; two 150 h. p. standard compound railway engines for the Edison General Electric Company, of Milwaukee, Wis.; one 150 h. p. standard compound railway engine for an electric railway in Portland, Me.; one 150 h. p. standard compound railway engine for the Edison Ore Concentrating Mill at Ogden, N. J.; one 150 h. p. standard compound railway engine for the Rock Creek Railway Company, of Washington, D. C.; two 200 h. p. standard compound electric light engines for the Norwalk and South Norwalk Electric Light Company, of Norwalk, Conn.; one 200 h. p. single-cylinder railway engine for the Gloucester Street Railway Company, of Gloucester, Mass.; one 80 h. p. single-cylinder engine for the Edison General Electric Company, of Groton, Mass.; one 60 h. p. single cylinder engine for the Edison General Electric Company, of Boston, Mass.; two 60 h. p. single-cylinder engines and one 80 h. p. single-cylinder engine for Messrs. Pierce and Thomas, of New York City, and two 30 h. p. single-cylinder engines for the Thomson-Houston Electric Company, of New York City. Messrs. McIntosh and Seymour have run the factory night and day almost since the beginning of their business, and are now building an addition to the machine shop which will double the floor space, making a machine shop building 430 feet long by 117 feet wide, which will be fitted with electric cranes, one of which has been ordered. The shipping facilities of this company are very good, as the New York Central and the Lehigh Valley railroads both have access to the machine shop with special tracks.

Business Notice.

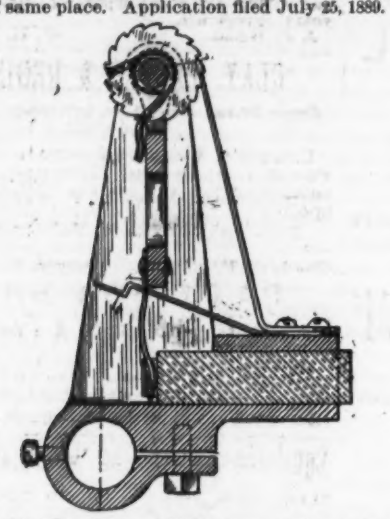
Battery Cut-Out, Cheap.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Company, of 105 South Warren street, Syracuse, N. Y.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

U. S. PATENTS ISSUED APRIL 28, 1891.

451,101. Electric-Arc Lamp; Charles Griffith Young, of New York. Application filed Jan. 3, 1889. In an electric-arc lamp, the combination with the upper carbon of a movable pulley, a lever carrying said pulley and connected with the lifting magnet of the lamp, a drum mounted on stationary supports below the pulley, a detent wheel geared to said drum, and a supporting band or ribbon connected at one end to the upper carbon and passing around the movable pulley to the stationary drum, the two parts of the band on opposite sides of the pulley being substantially parallel.

451,121. Electro-Mechanical Gong-Striking Machine; Thos. F. Gaynor, of Louisville, Ky., Assignor to the Gaynor Electric Co., of same place. Application filed July 25, 1889. The com-



No. 451,177.—BRUSH-HOLDER FOR DYNAMOS.

bination of the magnets, the two frame-plates having supports for the magnets, the pillars by which the frame-plates are secured together, an armature adjusting screw fitted in one of said pillars, and a magnet-adjusting screw in another one of the pillars.

451,125. Electric Meter; Frank R. Irving, of New York. Application filed Oct. 22, 1890. The combination, with a recording dial, of an indicator lever, its free end provided with a recording pen or pencil and mounted on a common pivot with an arm carrying an adjusting weight and an arm provided with a segmentally curved core surrounded by a correspondingly curved solenoid located in the circuit to be measured.

451,142. Electric Battery; Jean Theodore van Gestel, of New York, Assignor to the Crosby Electric Company, of same place. Application filed Aug. 29, 1890. In an electric generator the combination with the positive or carbon electrode thereof of a layer or coating of bioxide of manganese or its equivalent applied and united to the surface.

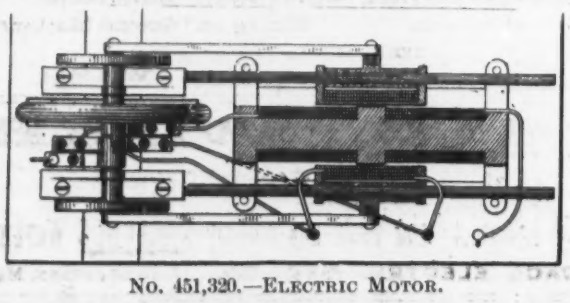
451,143. Telephone Call-Box; Frank Villiers-Stead and Elward Radford Hedgman, of London, England, Assignors to Knight Brothers, trustees, of New York, N. Y. Application filed July 28, 1890. The combination, with a normally open telephone circuit of a catch or detent and a flexible toe on the telephone switch, the same consituting a catch tripping or discharging mechanism brought into automatic operation by the act of preparing the instruments for another message.

451,149. Hanger for Electric Lamps; Peter Sylvanus Bates, of York, Pa., Assignor to W. F. Bay Stewart, of same place. Application filed Jan. 6, 1891. The invention comprises the fixed casing containing a drum upon which the flexible cord connecting the lamp in circuit is wound, and means for permitting the cord to be wound and unwound from the drum by taking hold of the lamp itself.

451,154. Electric Railway; Rudolph M. Hunter, of Philadelphia, Pa., Assignor by mesne assignments to the Thomson-Houston Electric Company, of Boston, Mass. Application filed March 18, 1886. In an electric railway, the combination of a main line railway having a working conductor with which the electric vehicle makes traveling contact, a branch railway also having a working conductor, a fixed source of electric supply, a line or supply conductor extending along the main line railway to and connecting with the working conductor of the branch, and conductors electrically connecting the supply conductor at intervals along its length with the working conductor of the main line railway.

451,155. Electrically Propelled Car; Rudolph M. Hunter, of Philadelphia, Pa. Application filed Jan. 3, 1891. The combination of two axles, a motor journaled upon each axle by means of journal bearings rigidly secured to the field magnets of said motors, a supporting frame hung from the axles through the bearings of the motors and a support between the said frame and the motors.

451,157. Electric Signal for Railways; Uriah S. Jackson, of Ossipee, N. H., Assignor of one-half to Harry F. Cady, of Lowell, Mass. Application filed June 26, 1890. In an electric signal system for railways the combination of electric signal boxes, each having



No. 451,320.—ELECTRIC MOTOR.

an electric magnet and mechanism for connecting it with pawls adapted to operate wheels having pins, index hands and dials, with an electric generator, system of circuit wires connected to said electric signal boxes and with the circuit terminals adapted to be made electrically operative by the action of an arm extending from the engine.

451,177. Brush-Holder for Dynamos; William LeRoy Emmet, of East Rockaway, N. Y. Application filed Sept. 18, 1890. In an organized brush-holder the combination of a frame, a pressure lever pivoted to said frame, means for imparting pressure to said lever, a brush socket, a catch to lock said lever back, and a brush normally loosely attached to said lever and unconnected with said brush socket. (See illustration.)

451,189. Electric-Arc Lamp; John H. R. Ward, of New York, Assignor to the Universal Arc Lamp Co., of same place. Application filed Dec. 11, 1890. In an arc lamp, the combination of an upper movable, hollow cylindrical carbon-holder, provided with a rectangular perforation upon one side thereof, an electric terminal brush, stationary relatively to the said carbon-holder, and whose free end presses upon said cylinder holder, so that when the perforation is at the same level as the brush the latter parts contact with the holder and an outwardly turned lip or dog's ear forming an integral portion of said brush, whereby the upward movement of the said holder will not catch the edge of said brush. (See illustration.)

451,190. Electric Switch; Le Roy S. White, of Waterbury, Conn., Assignor to the Electrical Appliance Manufacturing Company, of same place. Application filed Oct. 11, 1890. The combination of a base, contact plate secured thereto in pairs, a spindle having a cam secured thereon, and a contact bar having engagement with the cam, whereby the rotation of the spindle moves the bar away from the base, and a locking plate actuated by the spindle as the contact bar nears the limit of its adjustment away from the base to hold the contact bar in adjustment to make contact while the spindle is turned in the opposite direction.

451,208. Portable Magnetic Riffle; Wm. C. Edwards, of Holyoke, Mass., Assignor by direct and mesne assignments, of one-half to Roswell M. Fairchild, of same place, and Oscar S. Greenleaf, of Springfield, Mass. Application filed Dec. 11, 1890. A portable magnetic riffle consisting of a series of magnets enclosed in non-magnetic covering and fixed on a base holding the magnet poles elevated.

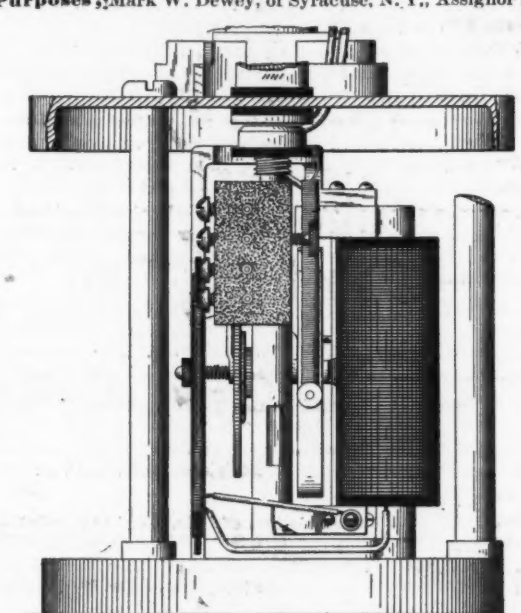
451,211. Trolley; Roderick Macrae, of Baltimore, Md., Assignor to the Donaldson-Macrea Electric Company, of same place. Application filed July 24, 1890. A trolley consisting of a frame and pulleys supported thereon on vertical pivoted pintles, and arranged to bear upon the side of the wire.

451,212. Starting Device for Electric Motors; Edward P. Sharp, of Boston, Mass. Application filed Dec. 5, 1890. The combination of a double or hook and cam ended armature and rotary contact arm and resistances, said armature being pivoted with the hook and contact end opposite the magnet and the cam end opposite to and for stopping the said arm at the last contact in a series of resistances.

451,226. Electric Indicator; John L. Ricketts, of Philadelphia, Pa. Application filed Nov. 28, 1890. The combination of an indicator magnet and an electric bell, a battery, a circuit including the battery indicator magnet and bell magnet, a circuit-closer in said circuit, and a gravity actuated switch for simultaneously shunting the indicating magnet and throwing the bell magnet into circuit, or vice versa, and a catch operated by the indicator magnet for holding said switch against action.

451,239. System for Electrically Supplying Hot Water for Consumption and Heating Purposes; Mark W. Dewey, of Syracuse, N. Y., Assignor to the Dewey Corporation, of same place. Application filed April 5, 1890. The method of supplying hot water for consumption or heating purposes, consisting in subjecting water contained in a pipe to a heating effect produced by an electric current in a portion of an electric circuit composed of said pipe, and circulating the water in the pipe leading to and through one or more localities, whereat the water may be released from the pipe or utilized for heating purposes.

451,240. Method of and Apparatus for Electrically Supplying Hot Water for Consumption and Heating Purposes; Mark W. Dewey, of Syracuse, N. Y., Assignor to the



No. 451,189.—ELECTRIC-ARC LAMP.

Dewey Corporation, of same place. Application filed April 5, 1890. The method of supplying hot water for consumption or heating purposes, consisting in subjecting water contained in a pipe to a heating effect produced by an electric current in a portion of an electric circuit composed of said pipe and circulating the water in the pipe leading to and through one or more localities, whereat the water may be released from the pipe or utilized for heating purposes.

451,242. Armature for Electric Motors and Generators; Perrin Grant, of Baltimore, Md. Application filed Nov. 28, 1890. A compound armature-core formed of a number of sections fitting around the shaft and having air spaces between their adjacent edges.

451,250. Electric-Arc Lamp; Addison G. Waterhouse, of Hartford, Conn. Application filed July 3, 1890. In an electric-arc lamp, the combination, with the carbon rod, of a feeding mechanism which will regulate the arc, a retarding mechanism provided with a clutch to engage the carbon rod and to travel downward with the rod, and a tripping mechanism carried by the retarding mechanism for controlling the position of the clutch.

451,267. Electric Switch; Horace T. Clark, of Bridgeport, Conn. Application filed Feb. 5, 1891. The combination with the movable bar and the movable handle of a pair of elbow-levers connected with one end to the bar and the other to the handle and having their joint free between the bar and handle, and a spring engaging one member of the pair and adapted to exert a constant force tending to extend said levers toward a straight line.

451,300. Insulating Swing Joint; Henry P. Drew, of New York. Application filed Jan. 24, 1891. The combination, with two flat joint-leaves, each having a radially extended, internally threaded socket and an annular groove laterally formed therein, which grooves provide parallel passages for gas, and are connected with their respective sockets by longitudinal passages that lie in parallel planes with the annular grooves, of an interposed joint-washer that is provided with a series of annularly arranged gas passages in it that conduct gas from one annular groove to the similar opposite groove, and an insulated clamping bolt and nut for the joint leaves.

451,308. Solenoid and Spool Magnet; Harvey S. Park, of Chicago, Ill. Application filed March 20, 1890. A combined solenoid and spool magnet comprising the helices, the core and the armature attached to a spring to prolong the travel of the core.

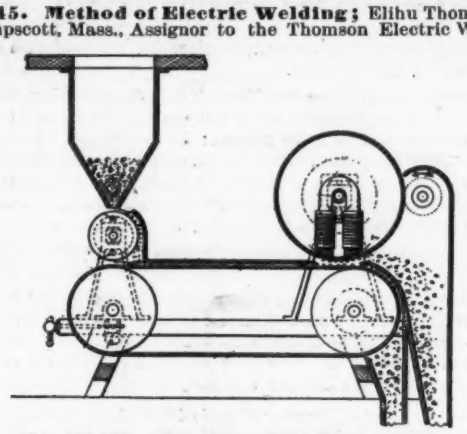
451,309. Electric-Arc Lamp; Rupert Schefbauer, of Paterson, N. J., Assignor to the Universal Arc Lamp Co., of New York. Application filed Oct. 3, 1890. The combination of an oscillating electromagnet located in a shunt circuit, a tension spring acting on said electromagnet, stationary pole pieces applied to the supporting frame of the lamp, a pinion on the axle of the oscillating electromagnet, a train of gear-wheels and an escapement supported by said arm, an upper carbon holder provided with a rack meshing with said pinion, and a stop device for said escapement.

451,312. Regulator for Dynamo-Electric Machines; Friedrich Tischendorfer, of Brooklyn, N. Y. Application filed Dec. 8, 1890. The method of regulating a dynamo-electric machine having auxiliary field-magnet poles in accordance with the current demands of the exterior or working circuit, consisting in increasing the magnetic effect in those auxiliary field-magnet cores lying next the brushes in the direction of the armature's rotation in sequence, and in similarly decreasing said effects in a reverse direction.

451,320. Electric Motor; Rudolf Eickemeyer, of Yonkers, N. Y. Application filed Aug. 28, 1890. In a reciprocating electric motor, an electro magnet embodying a central core and an inclosing magnetic shell, affording an annular magnetic field space and a longitudinally reciprocating armature helix or solenoid provided with suitable guide bearings and means for alternately reversing the electric currents supplied thereto. (See illustration.)

451,326. Tension and Cut-out Device for Electric Railways; Byron Jennings, of San Jose, Assignor of one-half to James Brusie, of Oakland, Cal. Application filed Sept. 19, 1890. The invention comprises a pair of plates suppported upon insulators, with a pulley journaled between them; a conductor passing around the pulley, thence around an insulated hanger having a weighted lever connected thereto; a second conductor secured or clamped to the plates, and a switchbox wherein the two conductors are connected or disconnected.

451,345. Method of Electric Welding; Elihu Thomson, of Swampscott, Mass., Assignor to the Thomson Electric Welding



No. 451,369.—MAGNETIC ORE SEPARATOR.

Company, of Maine. Application filed June 14, 1890. The method or process of welding or shaping metals by the agency of electricity and pressure applied through the rolls, hammers or other devices, consisting in, first, heating the part of the metal to be operated upon to the proper working temperature by passing an electric current through such part, then breaking the electric circuit, and, after the removal of the current, subjecting such part to the action of rolls, hammers, dies or other devices.

451,364. Electric Connection; Horatio J. Brewer, of New York. Application filed Sept. 5, 1890. A conductor terminal consisting of a bare wire having a sheathing of tin wrapped or folded over the bare portion of the wire, and constituting a connector for the conductor.

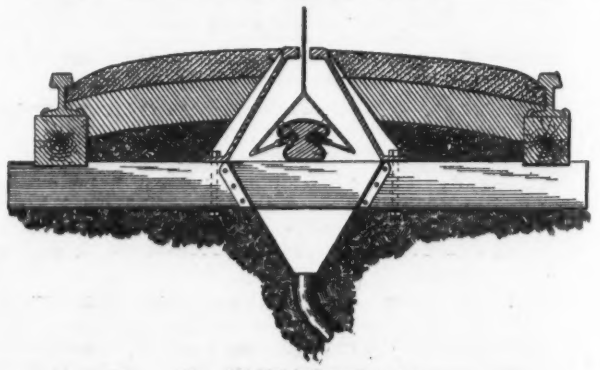
451,369. Magnetic Ore Separator; John P. Conkling, of New York, Assignor to Gurdon Conkling, of Glens Falls, N. Y. Application filed Aug. 7, 1889. In combination with the conveyer, a revolving cylinder composed of a shell of non-magnetic material, stationary magnets within said cylinder, and pole pieces adjacent to the surface of the conveyer, and made to extend across the conveyer and to connect the various magnets, so as to equalize the magnetic force. (See illustration.)

451,370. Magnetic Ore Separator; John P. Conkling, of Glens Falls, N. Y., Assignor to Gurdon Conkling, of same place. Application filed Sept. 13, 1890. The combination of a conveyer, a rotary shaft arranged transversely above the same, a non-magnetic cylinder attached to the shaft, several sets of electro-magnets attached to and rotating with the shaft, and each pole of every magnet having an independent segmental pole piece, forming the arc of a circle, and in superficial contact with the internal surface of the cylinder, and means for directing a current of electricity through each of the electromagnets in a set when the latter is presented opposite the conveyer.

451,377. Safety Connection for Electric Conductors; Robert Howe Gould, of Berlin, Germany. Application filed Sept. 11, 1890. In combination with a support, a clip connected thereto, a lever between the conductor and the clip detachably connected to the latter and a spring connected with the lever.

451,379. Insulator; Robt. D. Haines, of Corning, N. Y., Assignor of two-thirds to Alanson B. Houghton and Arthur A. Houghton, both of same place. Application filed Dec. 12, 1890. The process of manufacturing insulating conduits or coverings for electric conductors, which consists in forming a body or core of clay, drying it until it is firm and rigid, then dipping or submerging it in molten glass or otherwise covering it with glass in a plastic state, and finally annealing the glass-plated conduit in a suitable kiln. (See illustration.)

451,397. Electric Switch; Henry A. Chase, of Stoneham, Assignor of one-half to George W. Gregory, of Boston, Mass. Application filed Nov. 2, 1886. The combination of a number of circuits radiating from the main office with a switchboard having a movable switching device and a pole-changer and operating electromagnets, and local circuit therefor; the contact points of said pole-changer being connected with the movable switching device, whereby the said pole-changer may be placed in control of



No. 451,379.—INSULATOR.

any desired one of the circuits, and the movable switching device being provided with a key controlling the local circuit of the pole-changer.

451,402. Electric Railway; Ruldolph M. Hunter, of Philadelphia, Pa., Assignor to the Thomson-Houston Electric Company, of Connecticut. Application filed Dec. 2, 1890. The invention consists in arranging the conductor or conductors at an elevation above the railway track and at the curves, bringing the suspended conductor closer to the inner rail than the relative position occupied by the same conductor on the straight portions of the railway.

451,407. Method of Making Electrodes for Secondary Batteries; Henry Herbert Lloyd, of Camden, Assignor to the Electric Storage Battery Company, of Gloucester City, N. J. Application filed Oct. 27, 1890. The art of making and providing a battery plate or element with a grid, frame or supporting rim, which consists in preparing material to constitute the plate or element and forming the mass in a suitable appliance, and then applying thereto a molten material under a heavy pressure by means of compressed gas to cause said grid, frame or rim to be instantaneously and firmly attached to the plate or element.

451,414. Polarized Bell; Albert Storer, of Boston, Mass., Assignor to George W. Gregory, of same place. Application filed Aug. 7, 1890. In accordance with this invention an electromagnet comprising two coils wound on suitable cores and attached to a heelpiece is secured to one end of a bent bar magnet, each core of said electromagnet having secured to it a pole piece. A reinforcing block is secured to the opposite end of the bar magnet to which the polarized armature is connected by means of spring.